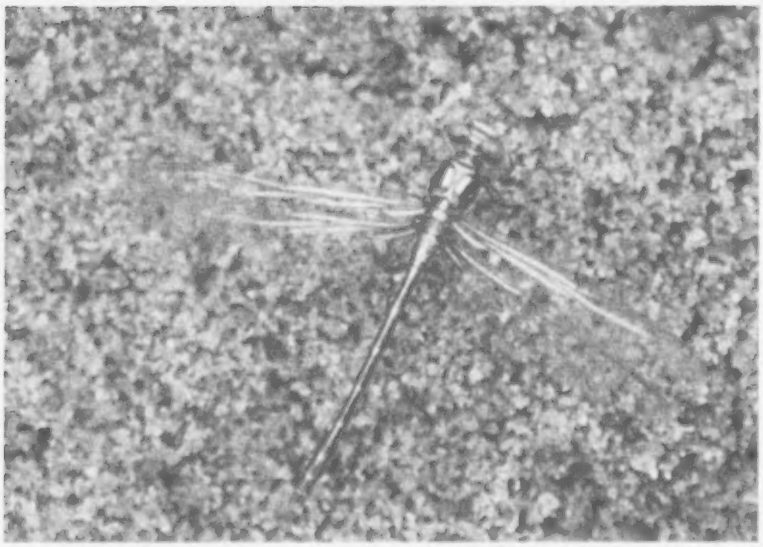
COSEWIC
Assessment and Status Report

on the

Riverine Clubtail
Stylurus amnicola

Boreal population
Great Lakes Plains population
Prairie population

in Canada



Boreal population - DATA DEFICIENT
Great Lakes Plains population - ENDANGERED
Prairie population - DATA DEFICIENT
2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Riverine Clubtail — Provided by report writer.

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COSEWIC
Assessment Summary

Assessment Summary – November 2012
Common name
Riverine Clubtail - Boreal population
Scientific name
Stylurus amnicola
Status
Data Deficient
Reason for designation
The isolated population of this dragonfly has been found on tributaries of the Gatineau and Ottawa rivers, and near Quebec City (it was first discovered near Hull). The lack of necessary data, including the likelihood of additional undocumented sites, resulted in a status of Data Deficient.
Occurrence
Quebec
Status history
Species considered in November 2012 and placed in the Data Deficient category.

Assessment Summary – November 2012
Common name
Riverine Clubtail - Great Lakes Plains population
Scientific name
Stylurus amnicola
Status
Endangered
Reason for designation
This dragonfly population is restricted to two small creeks that flow into Lake Erie. The impact of a variety of threats was determined to be very high, suggesting that there may be a substantial decline over the next decade. The threats include water withdrawal from the streams, pollution, and invasive alien species of fish that would feed on dragonfly larvae.
Occurrence
Ontario
Status history
Designated Endangered in November 2012.

Assessment Summary – November 2012
Common name
Riverine Clubtail - Prairie population
Scientific name
Stylurus amnicola
Status
Data Deficient
Reason for designation
This dragonfly population was discovered in 2004 along the Assiniboine and Red Rivers and more recently in Winnipeg. The lack of necessary data, including the likelihood of additional undocumented sites, resulted in a status of Data Deficient.
Occurrence
Manitoba
Status history
Species considered in November 2012 and placed in the Data Deficient category.

COSEWIC
Executive Summary

Riverine Clubtail
Stylurus amnicola

Boreal population
Great Lakes Plains population
Prairie population

Wildlife Species Description and Significance

Riverine Clubtail (*Stylurus amnicola*) is a dragonfly in the clubtail family. Members of the genus *Stylurus* are referred to as "hanging clubtails" for their habit of hanging vertically when perched on streamside vegetation. It is a small (47-49 mm long), slender dragonfly, with a prominent club at the end of the abdomen. The front of the thorax has a distinctive three-pointed star that distinguishes this species from other hanging clubtails. The abdomen is blackish with small yellow spots along the top and prominent yellow spots on the sides near the tip. Females have yellow patches along the sides of the abdomen. The hind legs are mostly black. The larvae are distinguished by their small size and shape of the abdominal segments and mouth parts. This species may serve as a useful environmental indicator.

Distribution

Riverine Clubtail occurs in eastern North America from southern Quebec and southern Manitoba south to southern Louisiana. The Canadian range of Riverine Clubtail may be divided into three separate regions: (1) the Ottawa River and St. Lawrence River valleys of Quebec; (2) Central north shore of Lake Erie in Ontario and (3) southeastern Manitoba.

Habitat

Riverine Clubtail larvae inhabit a wide variety of riverine habitats ranging in size from the St. Lawrence River to small creeks. Larvae are typically found in microhabitats with slow to moderate flow and fine sand or silt substrates where they burrow into the stream bed. Adults disperse from the river after emerging and feed in the forest canopy and other riparian vegetation. As with other dragonfly species that inhabit rivers and streams, water regulation, pollution and invasive species may be impairing their habitat.

Biology

Larvae spend most of their time buried just below the surface of the sediment in the bottom of the stream, breathing through the tip of the abdomen raised above the sediments. The larval stage probably lasts for two or more years prior to emergence in late June or early July. Newly emerged adults disperse inland to avoid predation until their exoskeleton hardens and they are able to fly well. Adults fly between mid July and early August, with peak numbers in mid July. Males cruise swiftly over the stream until they find a female. After mating, the female deposits eggs in the current of the open stream. Larvae obtain prey from the sediments using their prehensile labium. Adults are probably generalist and opportunist predators, feeding on small flying insects. Predators on Riverine Clubtail probably include fishes, birds, frogs, various mammals and insects including other dragonflies.

Population Sizes and Trends

The population size and trends are unknown.

Threats and Limiting Factors

The major threats to the Riverine Clubtail in Ontario, where threats are best understood, include water withdrawal for irrigation, water pollution, and invasive species. There is also increasing development resulting in habitat loss and increasing susceptibility to predators which are supported by human population including raccoons, and many kinds of birds for which human occupation provides both nesting and foraging sites. Some of these threats are also present in Quebec and Manitoba, but to a lesser extent.

Protection, Status, and Ranks

COSEWIC assessed both the Boreal population and the Prairie population of Riverine Clubtail as Data Deficient, and the Great Lakes population as Endangered in November 2012. The Riverine Clubtail is not currently protected under the *U.S. Endangered Species Act* or Canada's *Species at Risk Act*, or under provincial legislation in Quebec, Ontario, or Manitoba. No known Canadian sites are within provincial or federal parks.

In the NatureServe system, the Riverine Clubtail is ranked globally as G4 (Apparently Secure). Nationally, it is ranked as N3 (Vulnerable) in Canada and N4 in the US, S3 (Vulnerable) in Quebec, S1 (Critically Imperiled) in Ontario, and is unranked in Manitoba. In adjacent states it is ranked SX (Apparently Extirpated) to S3; it is rare but unranked in Minnesota.

TECHNICAL SUMMARY – Boreal population

Stylurus amnicola
Riverine Clubtail
Boreal population
Range of occurrence in Canada: Quebec

Gomphe riverain
Population boréale

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used)	2 yrs (assuming two-year larval stage)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence Using either discrete records or continuous (Picanoc R. and Quebec City records only) locations	25,686 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value). IAO is 40 km^2 using a 2 x 2 km grid and discrete records. If the two Picanoc River sites are treated as one continuous location and the two Quebec City sites are similarly treated, then the IAO is 68 km^2 (17 vs. 10 squares).	40 - 68 km²
Is the total population severely fragmented? Most or all habitat patches are apparently large enough to support a viable population.	No
Number of locations - Based on threats operating over a section of river 10 km in length and appropriate amalgamation of 11 sites (separated by 1 km).	9
Is there an observed continuing decline in extent of occurrence?	No
Is there an observed continuing decline in index of area of occupancy?	No
Is there an observed continuing decline in number of populations?	No
Is there an observed continuing decline in number of locations*?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	No

Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	n/a

Threats (actual or imminent, to populations or habitats)

No threats are well documented. Potential threats include water regulation, water pollution, and aquatic invasive species

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Ranked as SH (Possibly Extirpated) and S1 (Critically Imperiled) in states adjacent to Canadian populations. Minimum of 200 to 300 km to the nearest known US population.	
Is immigration known or possible?	Possible
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Status History

COSEWIC: Species considered in November 2012 and placed in the Data Deficient category.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Data Deficient	not applicable

Reasons for designation:

The isolated population of this dragonfly has been found on tributaries of the Gatineau and Ottawa rivers, and near Quebec City (it was first discovered near Hull). The lack of necessary data, including the likelihood of additional undocumented sites, resulted in a status of Data Deficient.

Applicability of Criteria

Criterion A: Not applicable. No information on decline in number of mature individuals.
Criterion B: Not applicable. Although the index of the area of occupancy is within the range for B2 Endangered, the criterion for severely fragmented is not met because the size of isolated populations may not be small and there is some dispersal capability. Although there are less than 10 locations, other locations are anticipated in this region and a decline is not projected and fluctuations are unknown.
Criterion C: Not applicable. No information on number of mature individuals.
Criterion D: Not applicable. Total number of mature individuals unknown and Index of Area of Occupancy exceeds 20 km^2.
Criterion E: None.

TECHNICAL SUMMARY – Great Lakes Plains population

Stylurus amnicola
Riverine Clubtail — Gomphe riverain
Great Lakes Plains Population — Population des plaines des Grands Lacs
Range of occurrence in Canada: Ontario, central north shore of Lake Erie

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used)	2 yrs (assuming two year larval stage)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence Minimum convex polygon versus continuous distribution	327-333 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value). If Big Otter Creek and Big Creek are each treated as continuous locations, then the IAO is 84 km^2 (21 vs. 12 squares)	48 - 84 km²
Is the total population severely fragmented?	No
Number of locations* - Based on threats operating over a section of river 10 km in length and appropriate amalgamation of 9-10 sites (separated by 1 km). A section of each of two small creeks within each of which threats would likely operate universally.	2
Is there an observed continuing decline in extent of occurrence?	No
Is there an observed continuing decline in index of area of occupancy?	No
Is there an observed continuing decline in number of populations	No
Is there an observed continuing decline in number of locations*?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? The observed decline is in the area, extent and quality of habitat.	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	n/a

Threats (actual or imminent, to populations or habitats)

Both creeks are small and susceptible to water withdrawal for irrigation as well as pollution which already exceeds acceptable standards. Invasive species and subsidized predators are also considered an important threat. Development in the area continues resulting in increased general pressure as well as loss of habitat and greater vulnerability to predators. The calculation of threat resulted in a threat impact of "very high."

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Ranked SX (Probably Extirpated) to S3 (Vulnerable) in states adjacent to Canadian populations. Minimum of 300 km to the nearest known US population.	
Is immigration known or possible?	Possible
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Status History

COSEWIC: Designated Endangered in November 2012.

Status and Reasons for Designation

Status:	Alpha-numeric code:
Endangered	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)

Reason for Designation:

This dragonfly population is restricted to two small creeks that flow into Lake Erie. The impact of a variety of threats was determined to be very high, suggesting that there may be a substantial decline over the next decade. The threats include water withdrawal from the streams, pollution, and invasive alien species of fish that would feed on dragonfly larvae.

Applicability of Criteria

Criterion A: Since the Threats Calculator is based on an estimate of the amount of the species affected and the amount of reduction for that amount, and may be estimated over a 10-year period based on trends, it provides an estimate of % decline and at a threat level of "very high" the decline range is 50-100%. Although this is an estimate, it is a plausible way of accounting for threats, especially when there are several kinds of threats that are likely increasing in magnitude. Possibly A3c(e) is applicable.
Criterion B: Meets B1 and B2ab(i,ii,iii,iv,v) with extent of occurrence (max. 333 km²) and index of area of occupancy (max. 84 km²) well under limits of 5,000 and 500 respectively. Also there are two locations. Severe fragmentation might be applied based on level of threat leading to decline but need not be evoked. As a result of high threat impact, a decline is projected in all listed b criteria.
Criterion C: Not applicable. No information on number of mature individuals.
Criterion D: Meets Threatened D2 since there are 2 (less than 5 locations) and there is a high threat impact considered over a time period of less than 10 years.
Criterion E: None.

TECHNICAL SUMMARY – Prairie population

Stylurus amnicola
Riverine Clubtail
Prairie population
Range of occurrence in Canada: southeastern Manitoba

Gomphe riverain
Population des prairies

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used)	2 yrs (assuming two-year larval stage)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence Using discrete records or Winnipeg as a continuous location	2491 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value). IAO is 56 km^2 using a 2 x 2 km grid and discrete known records. If the Winnipeg records are considered one continuous location then the IAO is 168 km^2 (42 vs. 14 squares).	56 - 168 km²
Is the total population severely fragmented? Most or all habitat patches are apparently large enough to support a viable population.	No
Number of locations* - Based on threats operating over a section of river 10 km in length and appropriate amalgamation of 13 sites (separated by 1 km).	5-6
Is there an observed continuing decline in extent of occurrence?	No
Is there an observed continuing decline in index of area of occupancy?	No
Is there an observed continuing decline in number of populations?	No
Is there an observed continuing decline in number of locations*?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Unknown

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	n/a

Threats (actual or imminent, to populations or habitats)

Dams, water pollution, aquatic invasive species

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Rare or uncommon in states adjacent to Canadian populations. Minimum of 200 to 300 km to the nearest known US population.	
Is immigration known or possible?	Possible
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Status History

COSEWIC: Species considered in November 2012 and placed in the Data Deficient category.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Data Deficient	not applicable

Reason for Designation:
This dragonfly population was discovered in 2004 along the Assiniboine and Red Rivers and more recently in Winnipeg. The lack of necessary data, including the likelihood of additional undocumented sites, resulted in a status of Data Deficient.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Total Population): Not applicable.
Criterion E (Quantitative Analysis): None.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2012)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Riverine Clubtail

Stylurus amnicola

Boreal population
Great Lakes Plains population
Prairie population

in Canada

2012

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Kingdom: Animalia - Animal, animals, animaux

Phylum: Arthropoda - arthropods, arthropodes, arthropods, Artrópode

Subphylum: Hexapoda - hexapods

Class: Insecta - insects, hexapoda, insectes, inseto

Subclass: Pterygota - winged insects, insects ailés

Infraclass: Palaeoptera - ancient winged insects

Order: Odonata Fabricius, 1793 – damselflies and dragonflies, demoiselles et libélula

Suborder: Anisoptera Selys, 1854 - dragonflies, libellules

Family: Gomphidae - clubtails, Clubtails

Genus: *Stylurus* Needham, 1897 - hanging clubtails

Species: *Stylurus amnicola* (Walsh, 1862) - Riverine Clubtail, gomphe riverin

Stylurus amnicola is a dragonfly in the clubtail family (Gomphidae). It was described by Walsh (1862) as *Gomphus amnicola*; it has also been referred to as *Gomphus abditus* (Butler, 1914) (Needham *et al.* 2000). Needham (1897) originally described *Stylurus* as a subgenus of *Gomphus*. Although *Stylurus* was subsequently raised to generic level (e.g., Williamson 1932; Needham 1948), Walker (1958) retained it as a subgenus of *Gomphus*. *Stylurus* was elevated once again to generic rank by Carle (1986) and has been accepted as a full genus in all recent official lists (Catling *et al.* 2005; Paulson and Dunkle 2009).

The family Gomphidae, whose member species are often referred to as Gomphids, is characterized by widely separated eyes and a terminally expanded abdomen in males. Members of the genus *Stylurus* are sometimes known as "hanging clubtails" as a result of their habit of hanging vertically from vegetation. The species is distinct and there are no subspecies.

Morphological Description

The Riverine Clubtail (Figures 1-4) is a small, slender dragonfly, with a prominent club at the end of the abdomen. Total body length ranges from 47-49 mm and the hind wing length is 29-33 mm (Walker 1958; Needham *et al.* 2000). Females are slightly larger than males. This species can be distinguished from other members of the genus *Stylurus* by the pattern on the front of the thorax, the yellow femora on the hind legs, and the small size. The front of the thorax has a three-pointed star (Figure 1) that distinguishes this species from other hanging clubtails occurring in its Canadian range (*S. laurae, S. notatus, S. spiniceps, S. scudderi,* and *S. plagiatus*) (Mead 2003; Jones *et al.* 2008; Paulson 2011). The abdomen is blackish with small yellow spots dorsally. Abdominal segments 8 and 9 have prominent lateral yellow spots in both sexes (Figures 1-3). Females also have yellow patches along the sides of the abdomen (Jones *et al.* 2008; Paulson 2011) (Figure 2). The sides of the thorax are mostly pale green (yellowish in young adults, Figure 3) with narrow dark stripes. The face is yellowish green with dark lines on the sutures and the eyes are at first yellowish-brown and grey (Figure 4) later becoming blue-green at maturity. The hind legs are black with pale femora.

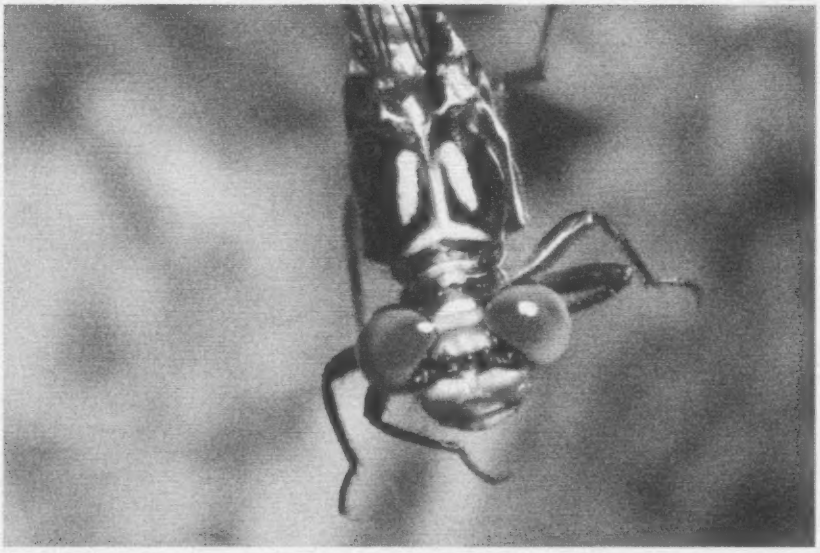

Figure 1. Riverine Clubtail showing the distinctive three-pointed star on the front of the thorax. The colour will change from yellow to grey-green as the dragonflies ages.

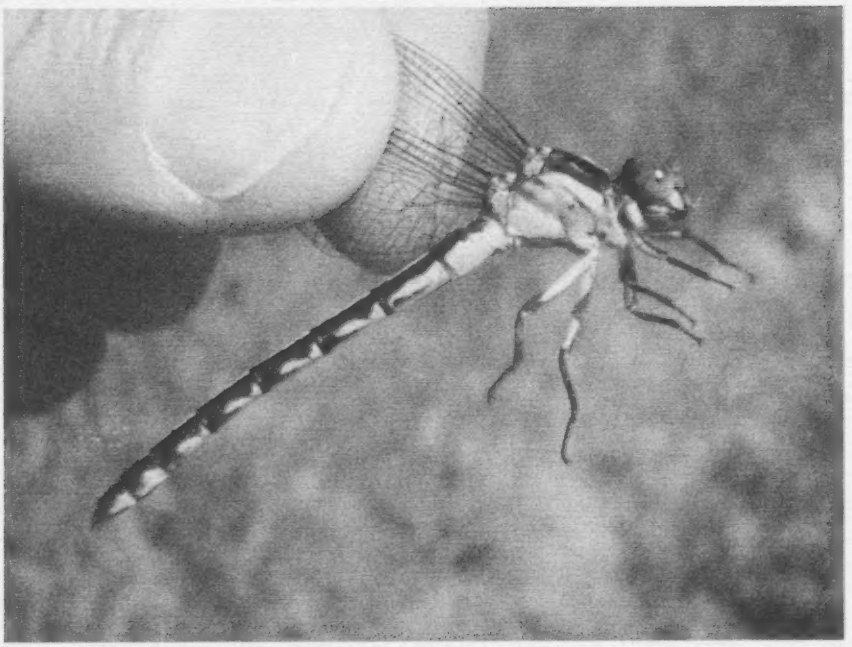

Figure 2. Female Riverine Clubtail showing pale femurs and yellow spots on the sides of the abdomen. Red River at Winnipeg MB, July 2011.

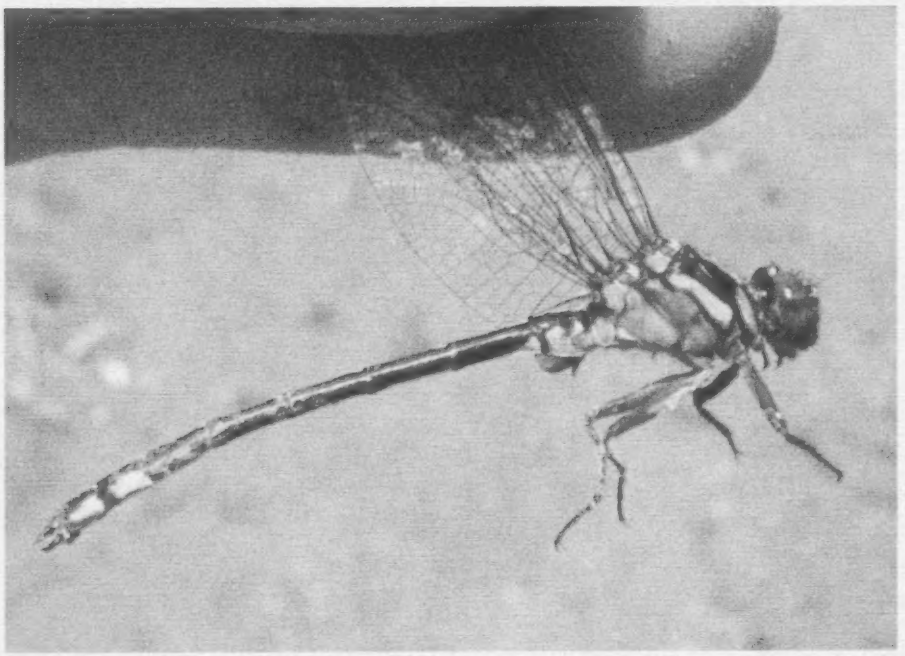

Figure 3. Male Riverine Clubtail. Big Otter Creek, ON, July 2008.

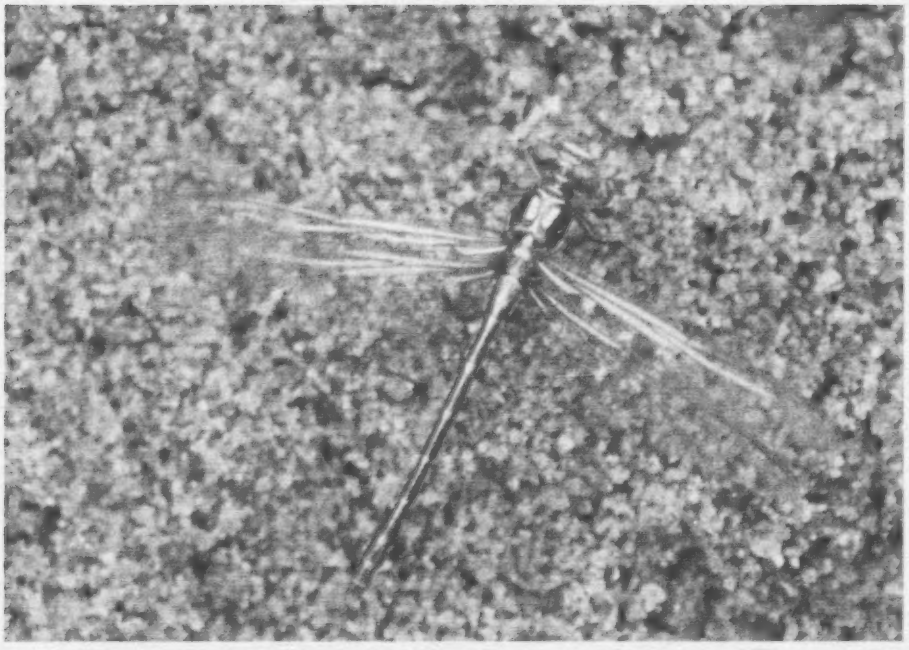

Figure 4. Teneral Riverine Clubtail. R. Petite-Nation, QC, July 2011.

The anterior hamules of the male's secondary genitalia are short and flattened with rounded tips and a backward slope (Walker 1958). The female subgenital plate is short and notched (Needham *et al.* 2000).

Stylurus larvae are distinguished from most other gomphid larvae by the lack of tibial burrowing hooks. Mature Riverine Clubtail larvae are 27 to 29 mm long and smaller than other sympatric *Stylurus* species (Catling 2000). In addition to their smaller size, Riverine Clubtail larvae can be distinguished from the other *Stylurus* species by the combination of abdominal segment 9 being wider than long and the strongly curved rather than straight or slightly convex ligula (leading edge of the prementum) (Bright and O'Brien 1999; Catling 2000; Garrison *et al.* 2006).

Population Spatial Structure and Variability

There is no information on population spatial structure and variability in populations of Riverine Clubtail in Canada or the US.

Designatable Units

The Canadian range of the Riverine Clubtail is divided into three separate regions: (1) the Ottawa River and St. Lawrence River valleys of Quebec; (2) Central north shore of Lake Erie in Ontario and (3) southcentral Manitoba. The three regions of occurrences are disjunct from each other by hundreds of kilometres and occur in three different Ecological Areas (COSEWIC 2009: Prairie, Great Lakes Plains, and Boreal). The species is discontinuously distributed through the US from Minnesota to North Carolina and north to New Hampshire. Canadian populations are separated by over 200 km from the nearest known US population (Figure 5).

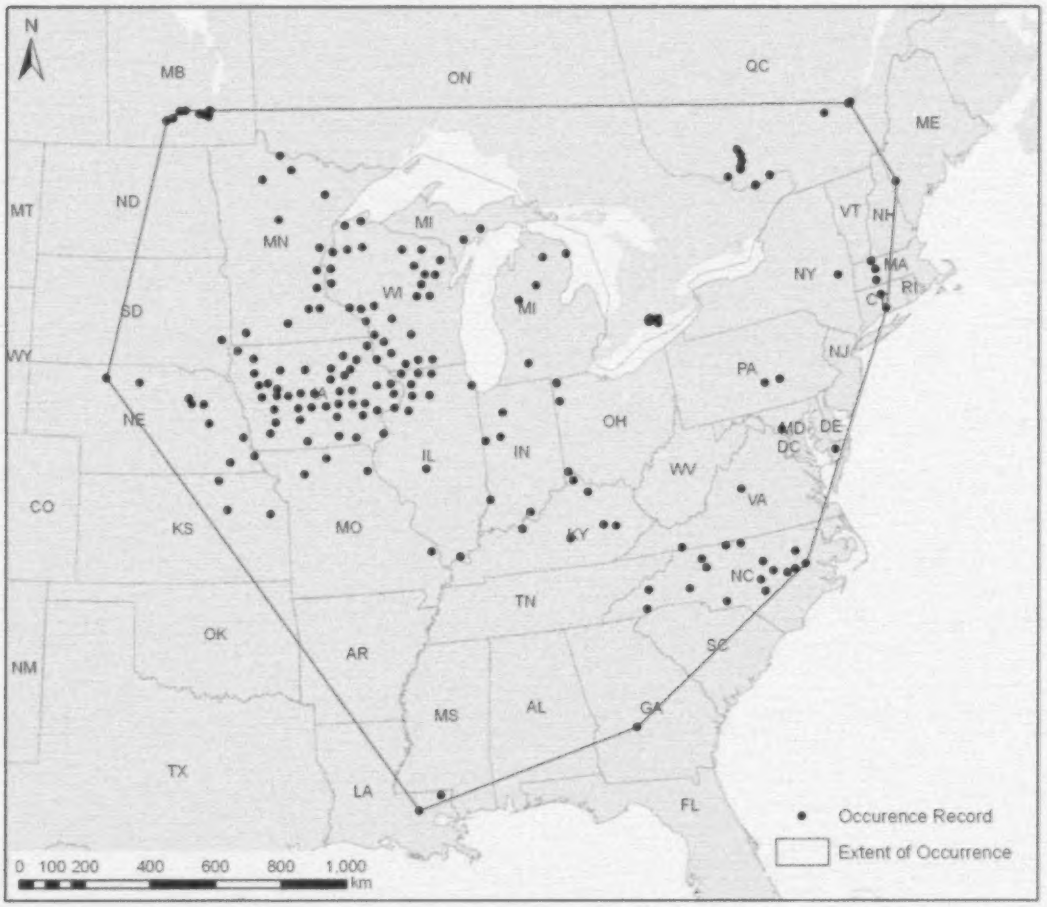

Figure 5. Global range of Riverine Clubtail (based on Odonata Central 2012 and updated for Canadian occurrences). Extent of occurrence (minimum convex polygon) is shown.

These three regions of occurrence are best treated as three designatable units because the distribution meets discreteness criterion number 2 (natural disjunction likely long established) and 3 (differing eco-geographic regions) as well as significance criterion 4 (loss of discrete population would result in an extensive gap in the range of the species in Canada). With respect to significance it is likely that occupation of both aquatic and terrestrial habitats in three regions each of which are part of different ecozones has also resulted in some local adaptation and divergence (2) as it has in other dragonflies. For example the widespread *Gomphus fraternus* has been recognized as a different and distinct subspecies in the Prairie and Boreal Plains ecozones (Catling 2008). The Quebec sites are in or on the edge of the Boreal Shield whereas the Lake Erie population is 500 km to the southeast within the Carolinian region of the Mixedwood Plain ecozone. Thus 2 discreteness criteria and one or possibly two significance criteria (COSEWIC 2012) may apply.

The major concern with regard to recognizing three designatable units is the possibility of additional occurrences. However, the eastern and western extremes of Canadian range are considered more likely to have additional records than the central area upon which the disjunction leading to the three designatable units is dependent. This conclusion is based on directed search and over 60,000 dragonfly records that are widely distributed in Ontario (Jones 2003) and have included surveys of many potential habitats of the species see under **DISTRIBUTION – Search Effort**.

Special Significance

Dragonflies are increasingly popular amongst naturalists as indicated by increasing numbers of field guides and organized dragonfly count events. Stream-dwelling clubtails in general are potential indicators of well-oxygenated, unpolluted streams (Bode *et al.* 1996). Aboriginal Traditional Knowledge was not found for this species.

DISTRIBUTION

Global Range

The Riverine Clubtail has an irregular range in central and eastern North America that encompasses three Canadian provinces and 25 states in the United States (Figure 5). There are disjunct populations in southern Ontario, southern Manitoba, the Ottawa and St. Lawrence valleys, and Louisiana and Georgia (Figure 5). It is not known from West Virginia (Olcott 2011), is apparently extirpated from Pennsylvania, and is known only from historical records from New York and Maryland (Table 1). Due to its rapid flight, mid-river patrolling behaviour, and tendency to perch high in the trees, adults are rarely seen except during emergence (Jones *et al.* 2008; Paulson 2011). As a result, its distribution is poorly known in parts of its range (Paulson 2009b). The Riverine Clubtail appears most abundant in Iowa and Wisconsin (Figure 5). The global maximum extent of occurrence includes approximately 3.8 million km^2.

Table 1. Summary of known records for Riverine Clubtail in Canada.

Prov.	Date	Location	Observer	Lat.	Lon.	# Ind.	Source
MB	2004/07/01	Assiniboine R., SE of Lavenham	M. L. Hughes	49.7598	-98.6426	2 ex	Hughes and Catling 2005
MB	2004/07/04	Assiniboine R. at Hwy 34 near Holland	M. L. Hughes	49.7004	-98.9013	1 ex	Hughes and Catling 2005
MB	2004/07/04	Red R. at Winnipeg (The Forks)	M. L. Hughes	49.8872	-97.1270	2 ex	Hughes and Catling 2005
MB	2004/07/06	Assiniboine R. at Headingly (bridge)	M. L. Hughes	49.8690	-97.4047	1 ex	Hughes and Catling 2005
MB	2004/07/06	Assiniboine R. at Headingly (Lido Plage)	M. L. Hughes	49.8741	-97.5111	1MC	Hughes and Catling 2005
MB	2004/07/06	Assiniboine R. at Hwy 34 near Holland	M. L. Hughes	49.6996	-98.9005	1 ex	Hughes and Catling 2005
MB	2004/07/06	Assiniboine R. at Portage la Prairie (below the dam)	M. L. Hughes	49.9493	-98.3252	5 ex	Hughes and Catling 2005
MB	2004/07/06	Assiniboine R. east of Portage la Prairie	M. L. Hughes	49.9693	-98.0976	2 ex	Hughes and Catling 2005
MB	2004/07/07	Assiniboine R. at Winnipeg (Assiniboine Park)	M. L. Hughes	49.8735	-97.2452	1 ex	Hughes and Catling 2005
MB	2004/07/09	Assiniboine R. at Headingly (Westmore Natural River Park)	M. L. Hughes	49.8628	-97.3770	1MC, IFC, 1 ex	Hughes and Catling 2005
MB	2004/07/24	Red R. at Winnipeg (Maple Grove Park)	M. L. Hughes	49.7941	-97.1263	1FC	Hughes and Catling 2005
MB	2008/07/09	Assiniboine R. at Winnipeg (Assiniboine Park)	L. de March	49.8764	-97.2327	1MC	MDS 2011
MB	2008/08/01	Assiniboine R. at Headingly (Westmore Natural River Park)	L. de March	49.8628	-97.3770	1MC	MDS 2011
MB	2009/06/30	Assiniboine R. at Headingly	R. Shettler	49.8667	-97.3681	1MC	MDS 2011
MB	2009/07/05	Bunn's Creek in Winnipeg	D. Dodgson	49.9545	-97.0653	1FC, 1MC	MDS 2011
MB	2010/06/28	Red R. at St. Boniface, downstream of Provencher	L. de March	49.8934	-97.1273	1FC	MDS 2011
MB	2010/07/01	Bunn's Creek in Winnipeg	D. Dodgson	49.9545	-97.0653	1MC	MDS 2011
MB	2010/07/02	Assiniboine R. at Winnipeg (Beauchemin Park)	D. Dodgson	49.8634	-97.2994	2 adult	MDS 2011
MB	2010/07/05	Red R. at Winnipeg, near Riverview hospital	L. de March	49.8681	-97.1149	1FC	MDS 2011
MB	2010/07/08	Assiniboine R. at Winnipeg (Beauchemin Park)	L. de March	49.8634	-97.2994	1FC, 2MC	MDS 2011
MB	2011/07/07	Red R. at North Perimeter Park, Winnipeg	A.G.Harris	49.9683	-97.0674	1 ex.	Harris and Foster 2011
MB	2011/07/07	Red R. Municipal park on east bank of Red River opposite The Forks Winnipeg MB	A.G.Harris	49.8954	-97.1281	3 im., 3 ex.	Harris and Foster 2011
ON	1999/07/11	Big Otter Creek at Elgin Rd #44, west of Eden, ON	P.M. Catling	42.7990	-80.7799	25 ad.	Catling and Brownell 1999
ON	1999/08/02	Big Otter Creek at Elgin Rd #38, w of Straffordville, ON	P.D. Pratt, E. Sinnott	42.7600	-80.8400	4+ ad.	Catling and Brownell 1999
ON	2000/07/01	Big Otter Creek at Elgin Rd. 45	P.M. Catling, V.R. Brownell	42.7135	-80.8388	2 im.	OOA 2005
ON	2000/07/06	Big Creek at N end of Rowan Mills Conservation Area	P.M. Catling, V.R. Brownell	42.6307	-80.5378	2 ad.	OOA 2005
ON	2000/07/17	Big Otter Creek at Reg. Rd. 38, north side, E of Richmond	P.S. Burke	42.7631	-80.8399	2 ad.	OOA 2005
ON	2000/07/31	Big Otter Creek at Eden Line (Reg. Rd. 44), north side	P.S. Burke, D.A. Sutherland	42.8008	-80.7787	5 ad.	OOA 2005
ON	2000/07/31	Big Otter Creek at Reg. Rd. 38, south side, E of Richmond	P.S. Burke	42.7631	-80.8399	6 ad.	OOA 2005

Prov.	Date	Location	Observer	Lat.	Lon.	# Ind.	Source
ON	2000/07/31	Big Otter Creek at Richmond Rd. (Reg. Rd. 43), S of Richmond	P.S. Burke	42.7577	-80.8472	2 ad.	OOA 2005
ON	2000/07/31	Big Otter Creek, south of Eden Line, approx. 3km W of Eden (site#1)	C.D. Jones, R.R. Russell	42.7949	-80.7840	5 ad.	OOA 2005
ON	2000/07/31	Big Otter Creek, south of Eden Line, approx. 3km W of Eden (site#2)	C.D. Jones, R.R. Russell	42.7938	-80.7860	3 ad.	OOA 2005
ON	2000/07/31	Big Otter Creek, south of Eden Line, approx. 3km W of Eden (site#3)	C.D. Jones, R.R. Russell	42.7924	-80.7871	3 ad.	OOA 2005
ON	2000/08/07	Big Creek at Cty. Rd. 1 (west of Glenshee)	P.S. Burke	42.7576	-80.5051	1 ad.	OOA 2005
ON	2002/07/18	Big Otter Creek at Cullonden Rd	P.Burke, C.J.Rothfels	42.7684	-80.8313	3; 1MC	OOA 2005
ON	2008/07/13	Big Otter Creek at Cullonden Rd	A.G.Harris, R.F.Foster	42.7677	-80.8314	1 ex.	Harris and Foster 2009
ON	2008/07/13	Big Otter Creek at Eden Line	A.G.Harris, R.F.Foster	42.7975	-80.7812	1 ex.	Harris and Foster 2009
ON	2008/07/14	Big Creek 0.7 km S of Walsingham	A.G.Harris, R.F.Foster	42.6681	-80.5320	1 ex.	Harris and Foster 2009
ON	2008/07/14	Big Creek at Spring Ardour	A.G.Harris, R.F.Foster	42.6657	-80.5334	2 ex.	Harris and Foster 2009
ON	2008/07/14	Big Creek at Spring Ardour	A.G.Harris, R.F.Foster	42.6670	-80.5330	1 ex.	Harris and Foster 2009
ON	2008/07/14	Big Creek between Regional Rd 1 and Highway 59	A.G.Harris, R.F.Foster	42.7127	-80.5282	1 ex.	Harris and Foster 2009
ON	2008/07/15	Big Otter Creek at Eden Line	A.G.Harris, R.F.Foster	42.7943	-80.7817	3 ex.	Harris and Foster 2009
ON	2008/07/15	Big Otter Creek S of Eden Line	A.G.Harris, R.F.Foster	42.7878	-80.7905	2 ad.	Harris and Foster 2009
ON	2012/07/20	Big Creek at 6th Concession	B. Solymar	42.6752	-80.5299	1 ex.	EarthTramper Consulting Inc. 2011
ON	2012/07/20	Big Creek at Norfolk Country Rd. #45	B. Solymar	42.7173	-80.5320	1 ex.	EarthTramper Consulting Inc. 2011
ON	2012/07/20	Big Otter Creek at Reg. Rd. #43 (Richmond)	B. Solymar	42.7552	-80.8464	3 ex.	EarthTramper Consulting Inc. 2011
ON	2012/07/20	Big Otter Creek at Reg. Rd. #46 (Culloden Rd.)	B. Solymar	42.7678	-80.8319	3 ex.	EarthTramper Consulting Inc. 2011
ON	2012/07/20	Big Otter Creek at Reg. Rd. #45 (Calton Line)	B. Solymar	42.7109	-80.8403	2 ex.	EarthTramper Consulting Inc. 2011
ON	2012/08/01	Big Creek, Paddle 4	B. Solymar	42.7037	-80.5131	1 ex.	EarthTramper Consulting Inc. 2011
QC	1928/06/29	Baie en face la Rose, Gatineau River QC (near Collège Saint-Alexandre, Gatineau-Hull)	L.M. Stohr	45.4911	-75.7509	3MC, 1FC	Walker 1928
QC	1995/06/30	Rivière Petite-Nation, above the falls near Plaisance QC	B. Ménard	45.6430	-75.1363	2MC, 2FC	Pilon & Lagace
QC	1995	Rivière Désert à Montcerf; Ch de Bois Franc Montcerf, near Maniwaki QC	B. Ménard	46.5379	-76.0334		Menard 1996
QC	1997/07/10	St. Lawrence River at l'anse du Moulin Banal, Saint-Augustine-de-Desmaures; near Quebec City, QC	J.M. Perron, Y. Ruel	46.7334	-71.4219	1 ad., 6 ex.	Perron and Ruel 1998
QC	1997	Gatineau River at Bouchette QC		46.2141	-75.9781		Menard 2012

Prov.	Date	Location	Observer	Lat.	Lon.	# Ind.	Source
QC	1997	St. Lawrence River at Plage Jacques-Cartier (Cap-Rouge) near Quebec City QC	J.M. Perron	46.7473	-71.3433	1 ad.	Perron 2012
QC	2003/07/12	Jacques-Cartier de Cap-Rouge near Quebec City	J.M. Perron	46.7473	-71.3433	une femelle	Perron 2012
QC	2003/07/14	Jacques-Cartier de Cap-Rouge near Quebec City	J.M. Perron	46.7473	-71.3433	deux femelles	Perron 2012
QC	2011/07/03	East bank of Gatineau River at Gatineau QC 1 km upstream from Collège Alexandre	A.G.Harris, R.F.Foster	45.4942	-75.7610	1 ten.	Harris and Foster 2011
QC	2011/07/04	Gatineau River at Maniwaki QC	A.G.Harris, R.F.Foster	46.3825	-75.9656	1 lar.	Harris and Foster 2011
QC	2011/07/04	Riviere Coulonge north of Fort Coulonge QC	A.G.Harris, R.F.Foster	45.9117	-76.6674	2 ex.	Harris and Foster 2011
QC	2011/07/05	Plaisance, Rivière de la Petite-Nation at North Nation Mills QC	A.G.Harris, R.F.Foster	45.6420	-75.1334	1 ex., 1 larv. & ten.	Harris and Foster 2011
QC	2011/07/04	Riviere Picanoc at Pont Cousineau, QC	A.G.Harris, R.F.Foster	46.0659	-76.1075	6 ex.; 1 larv.	Harris and Foster 2011
QC	2011/07/04	Riviere Picanoc east of Lac à Crete, QC	A.G.Harris, R.F.Foster	46.0115	-76.1263	1 ex.	Harris and Foster 2011
QC	2012/08/27	Rivière Bastican	P. Charest	46.7232	-72.4303	adults	Nathalie Desrosiers (Ministère des Ressources naturelles et de la Faune, Secteur Faune Québec
QC	2012/07/06	Rivière Bastican	P. Charest	46.7232	-72.4303	adults	

Canadian Range

The distribution of the Riverine Clubtail is poorly known in parts of Canada. There are only 61 documented records from 12 streams or rivers (Table 2, Figure 5). It was first discovered on the Gatineau River near Hull (now part of Gatineau) in 1928 (Walker 1928, 1935, 1958). In Canada as a whole there are 15 locations based on threats potentially operating over portions of rivers more than 10 km in length (10 km - minimum separation distance for river-breeding odonates from NatureServe 2012). Approximately 5% of the global range (as mapped in Paulson 2011) is in Canada. The maximum extent of occurrence (EO) in Canada is 693,551 km^2 as measured by minimum convex polygon. The maximum index of area of occupancy (IAO) encompasses 148 km^2 using a 2 km x 2 km grid (37 grid squares).

Table 2. State ranks for Riverine Clubtail in North America (NatureServe 2012).

Province / State	S-Rank	Notes
Quebec	S3	Known from 2 sites on the St. Lawrence River near Quebec City and 8 sites on rivers in the Gatineau area as well as Rivière Bastican
Ontario	S1	Known only from Big Creek and Big Otter Creek on the north shore of Lake Erie near Long Point
Manitoba	SNR	Known from the Red River and Dunn's Creek at Winnipeg and west along the Assiniboine River to Portage La Prairie
Alabama	S3S4*	Apparently erroneously listed for Alabama. No verified specimens and no known populations (R.S. Krotzer pers. comm. 2011).
Connecticut	S2	Known from Connecticut River (Wagner *et al.* 1996).
Georgia	S1	One historical record from Houston County, but no reports in many years despite significant survey efforts (G. Beaton pers. comm. 2011).
Iowa	S3	37 counties throughout the state (Iowa Odonata Survey 2012)
Illinois	S2	Specimens from 13 sites from northern to southern Illinois counties (1958 - 2011) (Cashatt pers. comm. 2011).
Indiana	S1S2	Recorded from 6 counties (Odonata Central 2012; USGS 2012)
Kansas	S2?**	Rare in medium sized sand-bottom streams in northeastern Kansas (Beckemeyer 1997). The condition of sand bottom streams in this area is generally poor (Busby pers. comm. 2011)
Kentucky	S2	No known change in status, but little recent survey effort (E. Laudermilk pers. comm. 2011).
Louisiana	SNR	Known from 2 counties in northeast corner of state. No known change in status (B. Gregory pers. comm. 2011)
Maine	SNR	One recent exuvia record from Oxford County (MDDS 2009)
Maryland	SH	Known from Montgomery County over 40 years ago but not since (Czaplak 2012; Odonata Central 2012) and ranked as Historical or Extirpated (J. Frye pers. comm. 2011)
Massachusetts	S2**	Recently downlisted from S1. Endangered. Populations in the Connecticut and Merrimack rivers. Other rivers are smaller and none appear to support Riverine Clubtail populations. No specific threats identified, but likely include damming, rapid water level changes (including boat wakes), nonpoint source pollution, removal of riparian vegetation, and conversion of natural vegetation into developed areas (Harper pers. comm. 2011).
Michigan	S1S2	Known from 6 counties in the Upper and Lower Peninsula (Odonata Central 2011) although only 3 may be extant (Michigan Natural Features Inventory 2007)
Minnesota	SNR	Widespread across the state but apparently not common anywhere (Baker pers. comm. 2011; Mead pers. comm. 2011). Found at two locations on Rainy River along international border in northwestern Ontario.
Missouri	SNR	Probably scattered throughout northern Missouri in low gradient, even channelized stream reaches with sand/silt substrates. No exuviae surveys have been conducted (Vogt 2011 pers. comm.).
Nebraska	SNR	Records from 9 counties (Paseka 2012).
New Hampshire	S3	Listed it as Special Concern, but more widespread than originally believed. Occurs along the Connecticut and Merrimack rivers. Recorded from approx. 18-20 sites and often abundant where it occurs (Cairn pers. comm. 2011; Hunt pers. comm. 2011).
New York	SH	Only one historical record from Albany County in eastern New York (Odonata Central 2012) and considered Possibly Extirpated (NatureServe 2012)

Province / State	S-Rank	Notes
North Carolina	S3?	Apparently rare, to locally uncommon. Widely scattered in the lower mountains, Piedmont, and western half of the Coastal Plain. Apparently declining. No reports since about the 1970s, but possibly overlooked (LeGrand 2011; The Dragonflies and Damselflies of North Carolina 2011).
North Dakota	SNR	No state records (Paulson 2009)
Ohio	S2	15 records from three counties dating back to 1900. Most recent record (a larva) from 1999 in the Ohio River. Apparently rare, but reason unclear and needs review (R.C. Glotzhober pers. comm. 2011).
Pennsylvania	SX	Formerly in a three-county area in south-central PA along the Susquehanna River (Cumberland, Dauphin and Perry Co). Riverbeds mostly bedrock with some cobble / gravel / sand (B. Leppo pers. comm. 2011).
South Carolina	SNR	Known from 1 county in the northwest corner of the state (NPWRC 2006)
South Dakota	SNR	No change in status according to most recent field surveys (R. Howell pers. comm. 2011).
Tennessee	SNR**	No state records. Formerly erroneously listed as S3? and S2S3 (R. Connors pers. comm. 2011; D. Withers pers. comm. 2011).
Virginia	S1	Found 3 times in Virginia, once along the New River (1977) in the western part of the state and twice along the James River (1928 and 2007) in eastern Virginia. Both are large rivers (S. Roble pers. comm. 2011).
Vermont	S1	Known from two sites in the SE corner of the state. It hasn't been observed elsewhere despite some recent focused surveys on large rivers throughout the state. Listed as a Species of Greatest Conservation Need (Ferguson pers. comm. 2011).
West Virginia	SNR	No state records despite recent odonate atlas efforts (Olcott 2011)
Wisconsin	S3**	No longer tracked as a rare species. Recently changed from S2S4 (W. Smith pers. comm. 2011).

* S-rank is inaccurate

** S-rank recently changed and not reflected in NatureServe (2011)

The range of the Riverine Clubtail is made up of three disjunct regions of Canada: (1) the Ottawa River and St. Lawrence River valleys of Quebec; (2) Central north shore of Lake Erie in Ontario and (3) southcentral Manitoba. These are discussed separately in the following paragraphs.

(1) Boreal Population - Quebec (Figure 6)

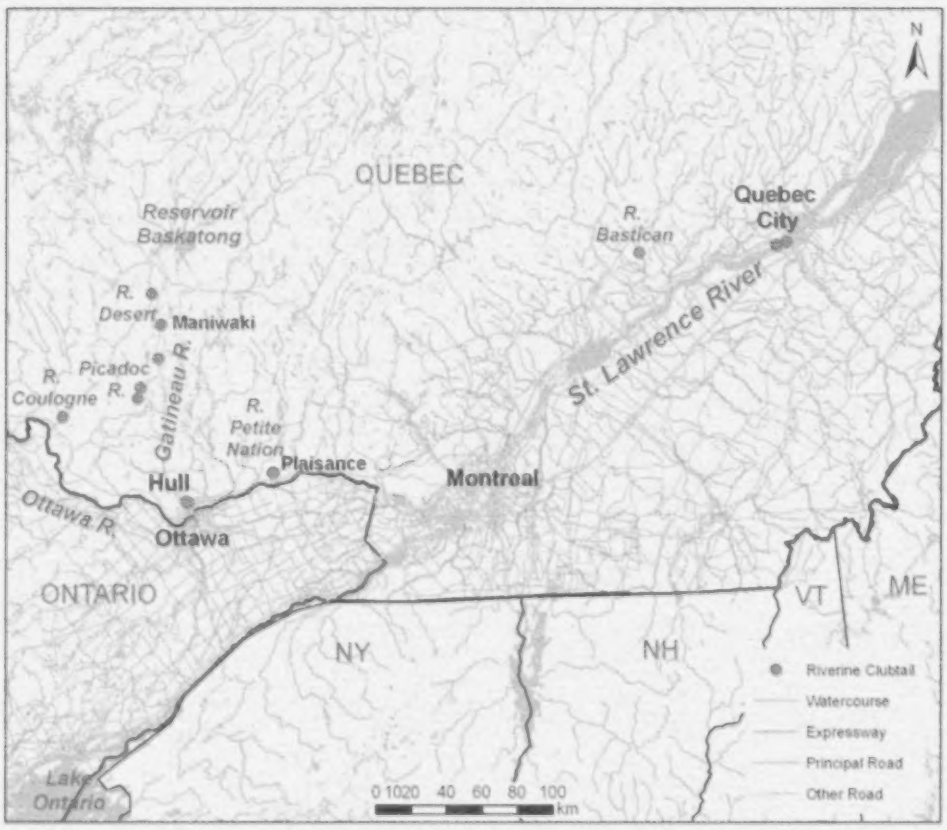

Figure 6. Distribution of Riverine Clubtail in Quebec.

Recently the Riverine Clubtail was discovered at Bouchette over 100 km farther upstream from its first discovery near Hull (Ménard pers. comm. 2012) and at Maniwaki (Harris and Foster 2011). It has also been found on two Gatineau tributaries: the Rivière Désert near Maniwaki (Ménard 1996) and two sites approximately 6 km apart on the Picanoc River (Harris and Foster 2011). The Riverine Clubtail is known from single sites on two other tributaries of the Ottawa River: the Rivière de la Petite-Nation near Plaisance (Ménard 1996) and the Rivière Coulonge west of Hull. The species has also been found at two sites on the St. Lawrence River near Quebec City that are approximately 6 km apart (Perron and Ruel 1998; Pilon and Lagacé 1998; Perron pers. comm. 2012). More recently there have been two observations with photographs of adult *Stylurus amnicola* at Rivière Bastican (Québec). The photographs were taken by Pierrette Charest (odonatologue) and identification confirmed by Michel Savard.

The Quebec records represent a total of 9 locations: one each on the Coulonge, Picanoc, Désert, Petite-Nation, Bastican and St. Lawrence rivers, as well as three on the Gatineau River. The two sites on the Picanoc River are considered one location due to their close proximity, as is the case for St. Lawrence River. The known sites on the Gatineau River are considered separate locations since they are scattered over 120 km of river, are separated from each other by at least 20 km, and may respond differently to threats from water level regulation and invasive species due to intervening hydroelectric dams. The extent of occurrence (EO) for the Quebec occurrences is 25,686 km^2 using either discrete records or continuous (Picanoc R. and Quebec City records only) locations (Figure 7). The index of area of occupancy (IAO) is 40 km^2 using a 2 x 2 km grid and discrete records (Figure 8). If the two Picanoc River sites are treated as one continuous location and the two Quebec City sites are similarly treated, then the IAO is 68 km^2 (16 vs 10 squares).

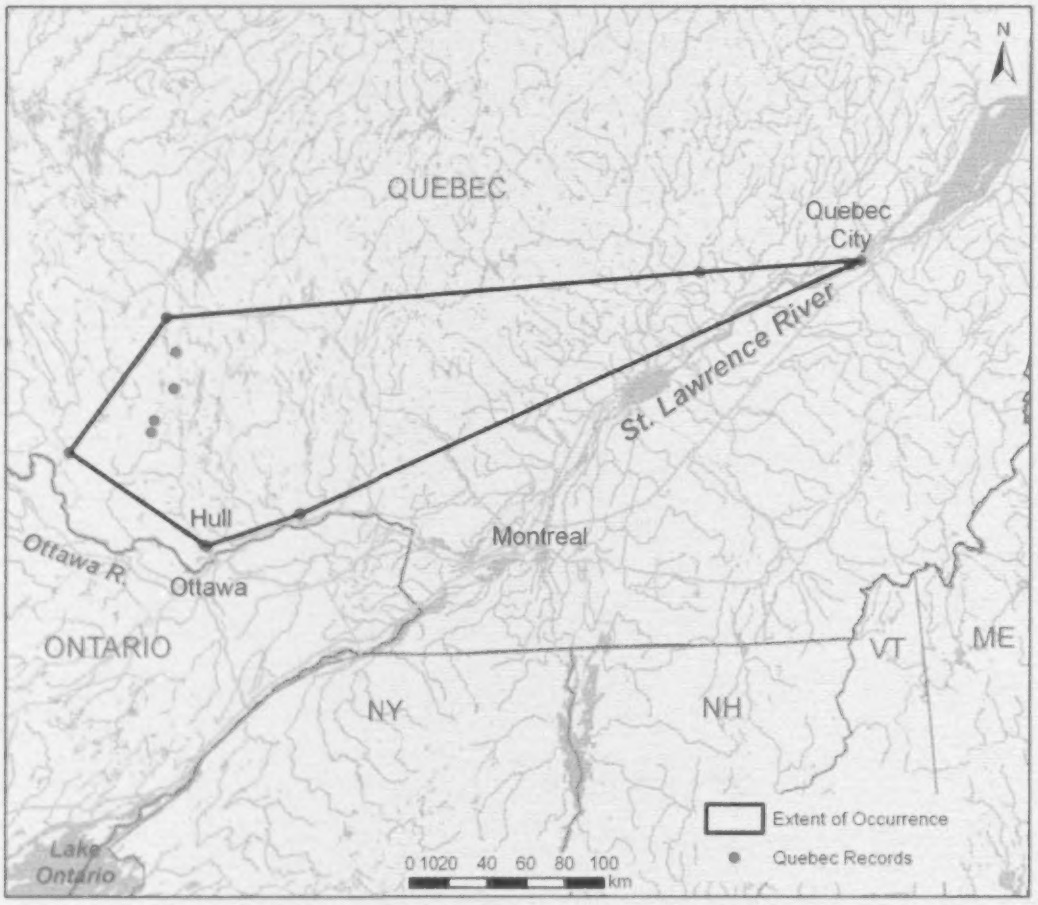

Figure 7. Showing method of calculation of extent of occurrence which is 25,686 km^2 using either discrete records or continuous (Picanoc R. and Quebec City records only) sites.

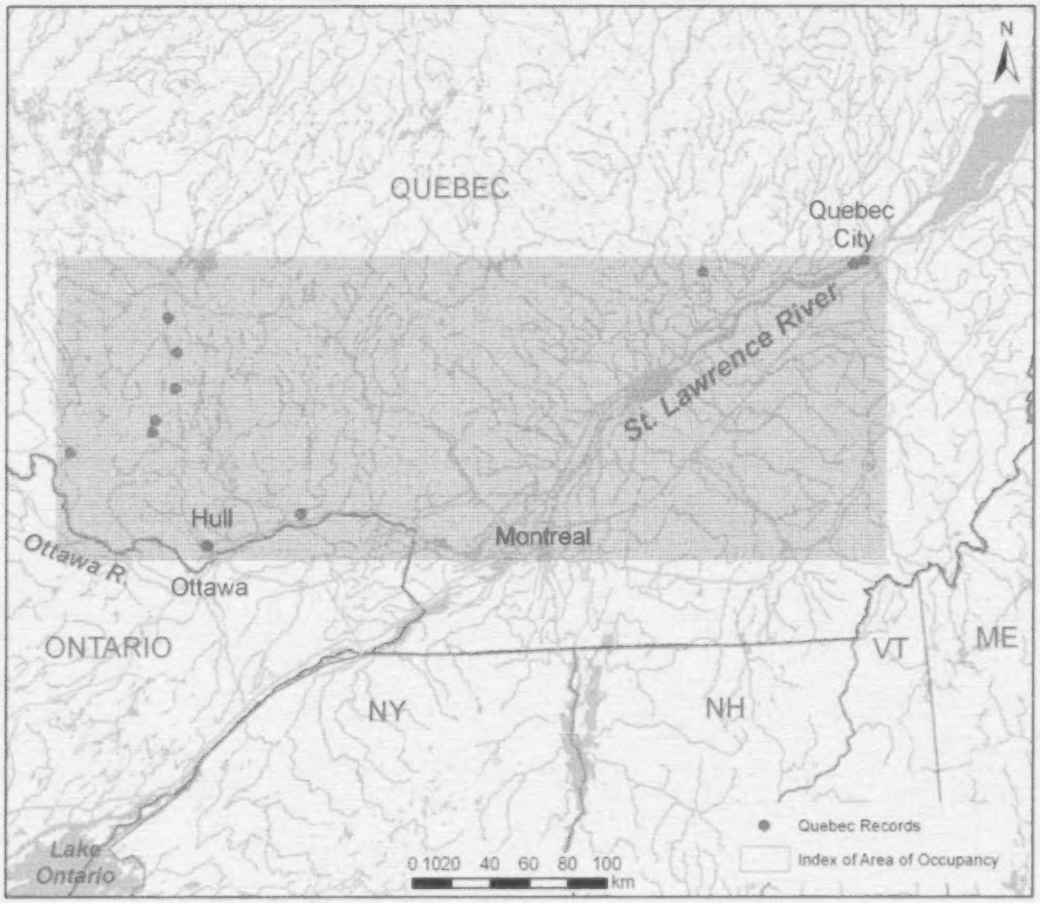

Figure 8. The calculation for index of area of occupancy in Quebec. If the two Picanoc River sites are treated as one continuous location and the two Quebec City sites are similarly treated, then the IAO is 68 km^2 (17 vs. 10 squares).

(2) Great Lakes Plains Population - Ontario (Figure 9)

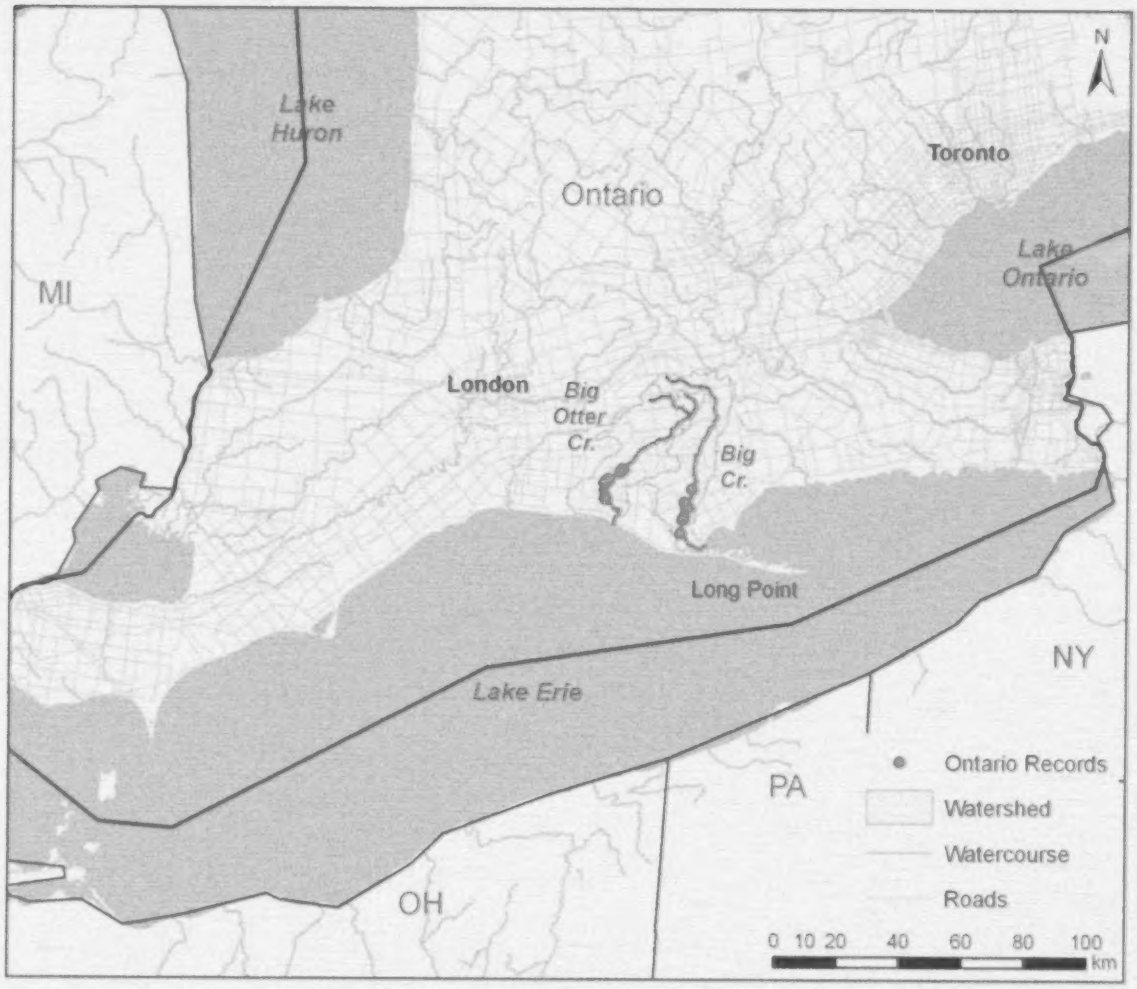

Figure 9. Distribution of Riverine Clubtail in Ontario.

The Riverine Clubtail was first reported from Ontario in 1999 on Big Otter Creek near Long Point on Lake Erie (Catling *et al.* 1999). It was first observed on adjacent Big Creek the following year and has since been found scattered along 19 km on both Big and Big Otter creeks. These records are apparently disjunct from the main portion of its range as it has not been found elsewhere in Ontario and no extant populations are known from adjacent portions of New York, Pennsylvania, Ohio, or Michigan. The nearest known US occurrence is over 300 km distant in northwestern Ohio (Glotzhober pers. comm. 2011). This disjunction may be considered real based on extensive inventory effort in that state. As with Laura's Clubtail (*S. laurae,* COSEWIC 2010), southern Ontario populations of Riverine Clubtail are considered as two locations since Big Otter and Big creeks are separated by approximately 23 km. Any major threats would operate throughout each creek since they are essentially uninterrupted and they are also both small (Table 3). The extent of occurrence (EO) for the Ontario occurrences is 333 – 337 km^2 (minimum convex polygon versus continuous distribution, Figures 10, 11), and the index of area of occupancy (IAO) is 48 km^2 using a 2 x 2 km grid and discrete known records (Figure 12). If Big Otter Creek and Big Creek are each treated as continuous locations, then the IAO is 84 km^2 (21 vs. 12 squares).

Table 3. Attributes of rivers supporting Riverine Clubtail (data from Water Survey of Canada 2012, Benke and Cushing 2005).

Stream	Mean Annual Discharge (m^3/s)	Watershed Area (km^2)	pH
Red R., MB	236*	287,500*	8.1
Assiniboine R., MB	47	162,000	8.2
Big Creek, ON	7	750	8.3
Big Otter Creek, ON	9	712	8.4
R. Coulonge, QC	75	5,150	-
R. Picanoc, QC	18	1,290	-
R. Petite-Nation, QC	22	1,990	-
R. Gatineau, QC	353	40,254	-
St. Lawrence, QC	12,600	574,000	7.5 - 8.5
R. Bastican			
R. Désert			

* including the Assiniboine

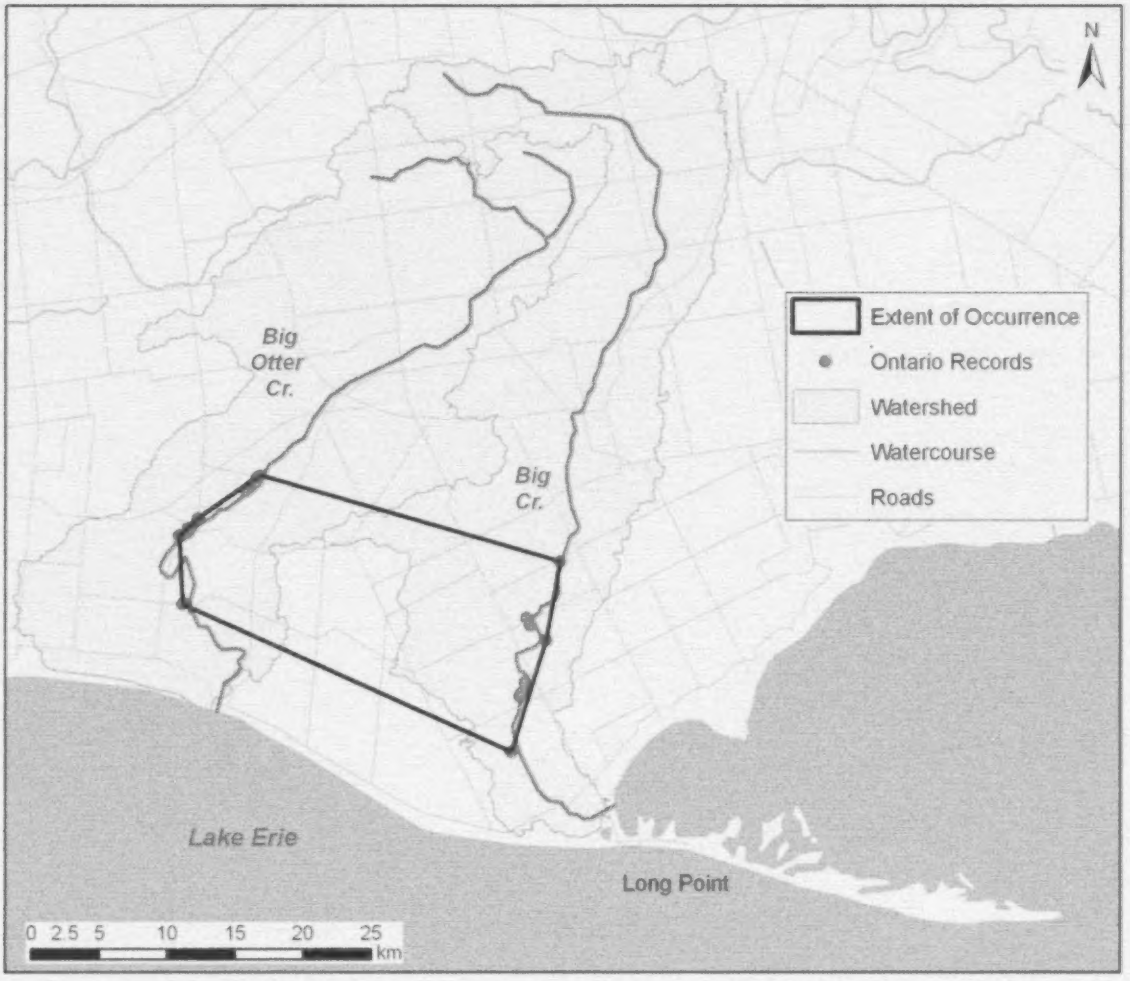

Figure 10. Calculation of extent of occurrence (EO) for the Ontario sites using discrete records. Based on known records (i.e., using discontinuous points), the extent of occurrence is 327 km^2.

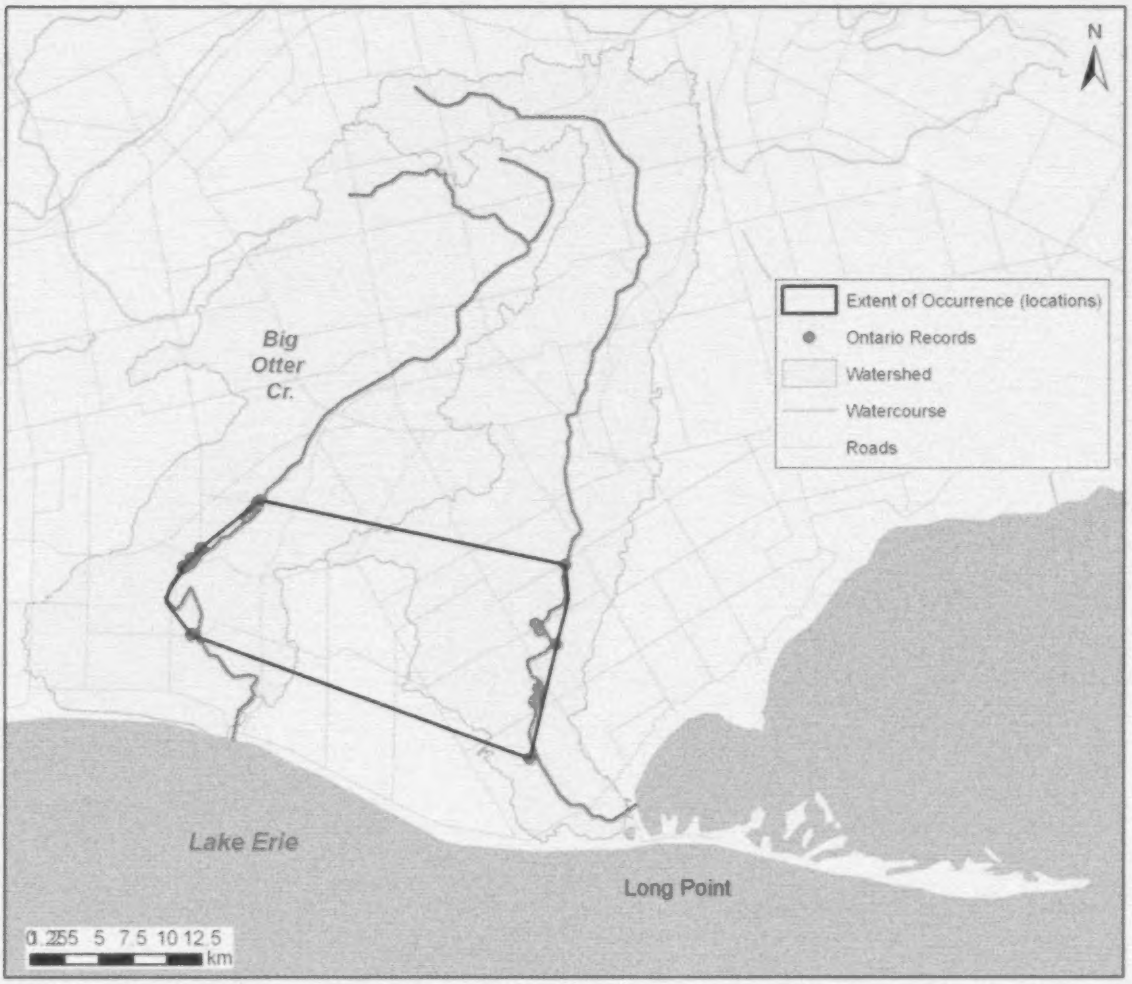

Figure 11. Calculation of extent of occurrence (EO) for the Ontario sites using continuous locations (minor difference to encompass loops of the creek). Extent of occurrence based on continuous distribution in Big Otter Creek and Big Creek is 333 km^2. The minor difference is from including loops of the creek between known sites that are excluded when making a minimum convex polygon using the discrete records.

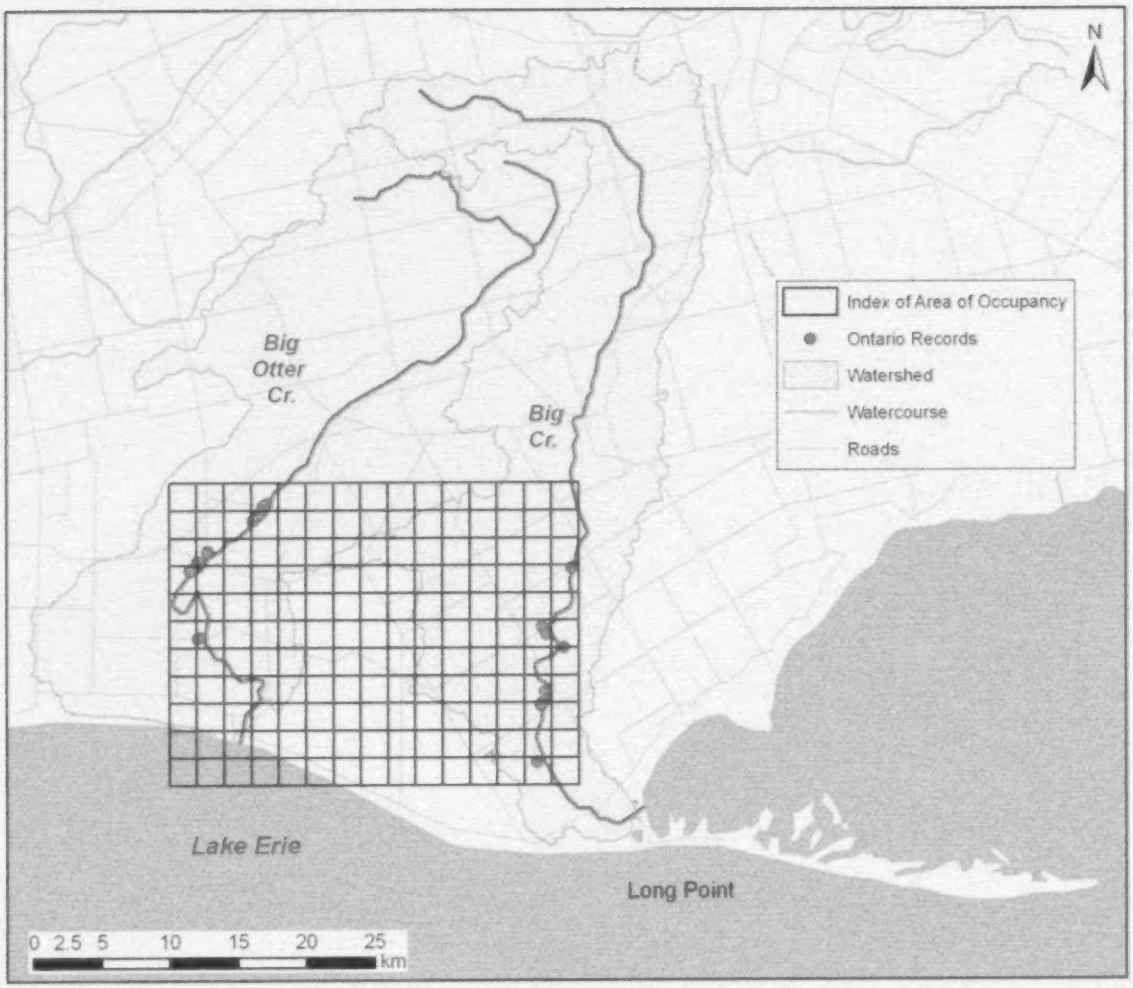

Figure 12. Calculation of the index of the area of occupancy (IAO) for the Ontario region of occurrence. It is 48 km^2 using a 2 x 2 km grid and discrete known records. If Big Otter Creek and Big Creek are each treated as continuous locations, then the IAO is 84 km^2 (21 vs. 12 squares).

(3) Prairie Population –Southeastern Manitoba (Figure 13)

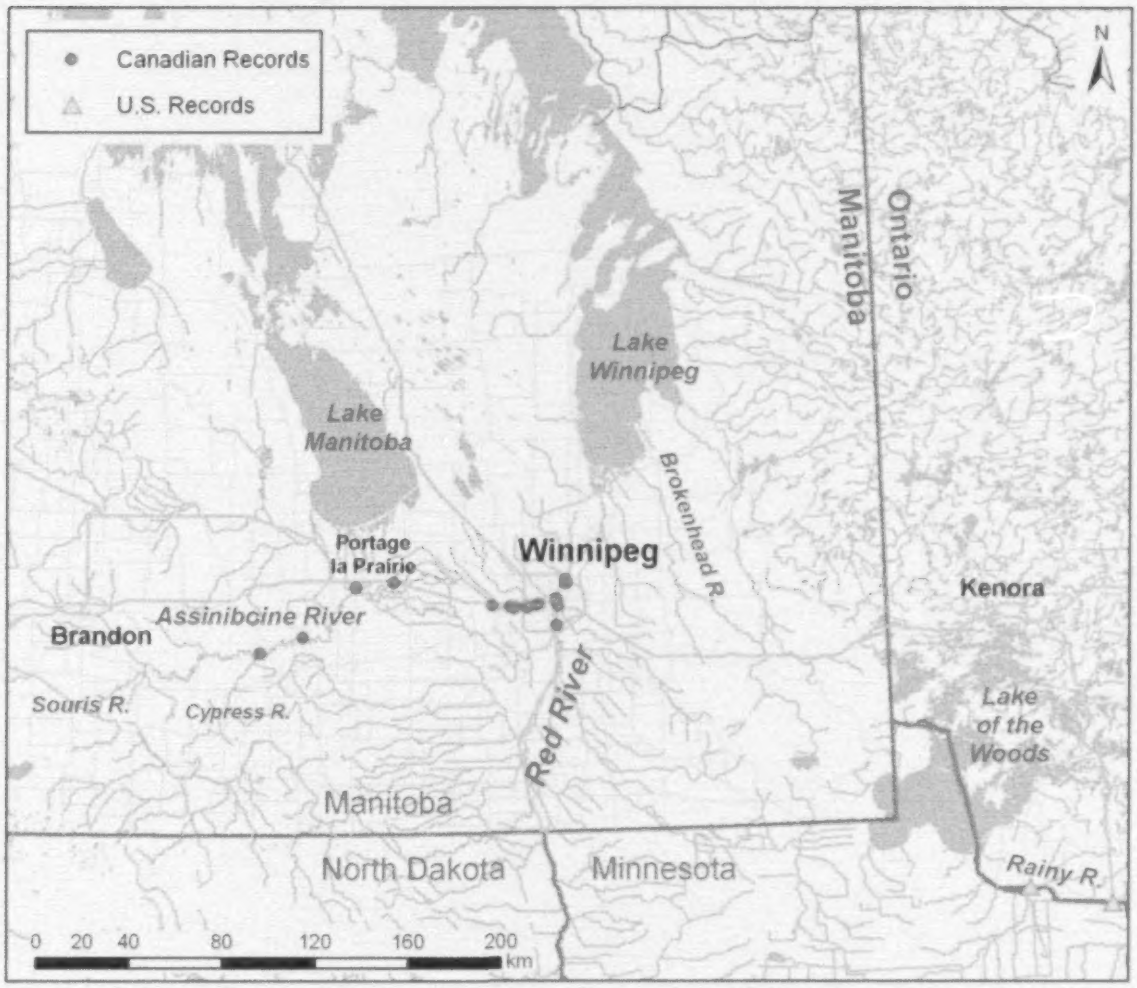

Figure 13. Distribution of Riverine Clubtail in Manitoba.

The Riverine Clubtail was recently discovered in 2004 in southern Manitoba along the Assiniboine and Red rivers (Hughes and Catling 2005). It has since been found at additional locations along the Assiniboine River and Bunn's Creek in Winnipeg (de March pers. comm. 2010; Dodgson pers. comm. 2010).

The Manitoba sites represent five locations: those in or near Winnipeg, and another four locations widely scattered over 100 km of the Assiniboine River to the west. The sites in and immediately upstream and downstream of Winnipeg on the Bunn's Creek, Assiniboine and Red rivers are in close proximity to each other and would likely be similarly impacted by the most likely threats such as poor water quality, invasive species, and urban landscape changes. The sites to the west are separated from each other by at least 20 km and have some intervening dams that may affect the distribution of exotic species. The extent of occurrence (EO) for the Manitoba occurrences is 2491 km^2 (Figure 14), and the index of area of occupancy (IAO) is 56 - 168 km^2, depending on whether or not the Winnipeg records are considered a continuous location (Figure 15). The nearest U.S. locations to the Manitoba occurrences are approximately 200 km to the southeast.

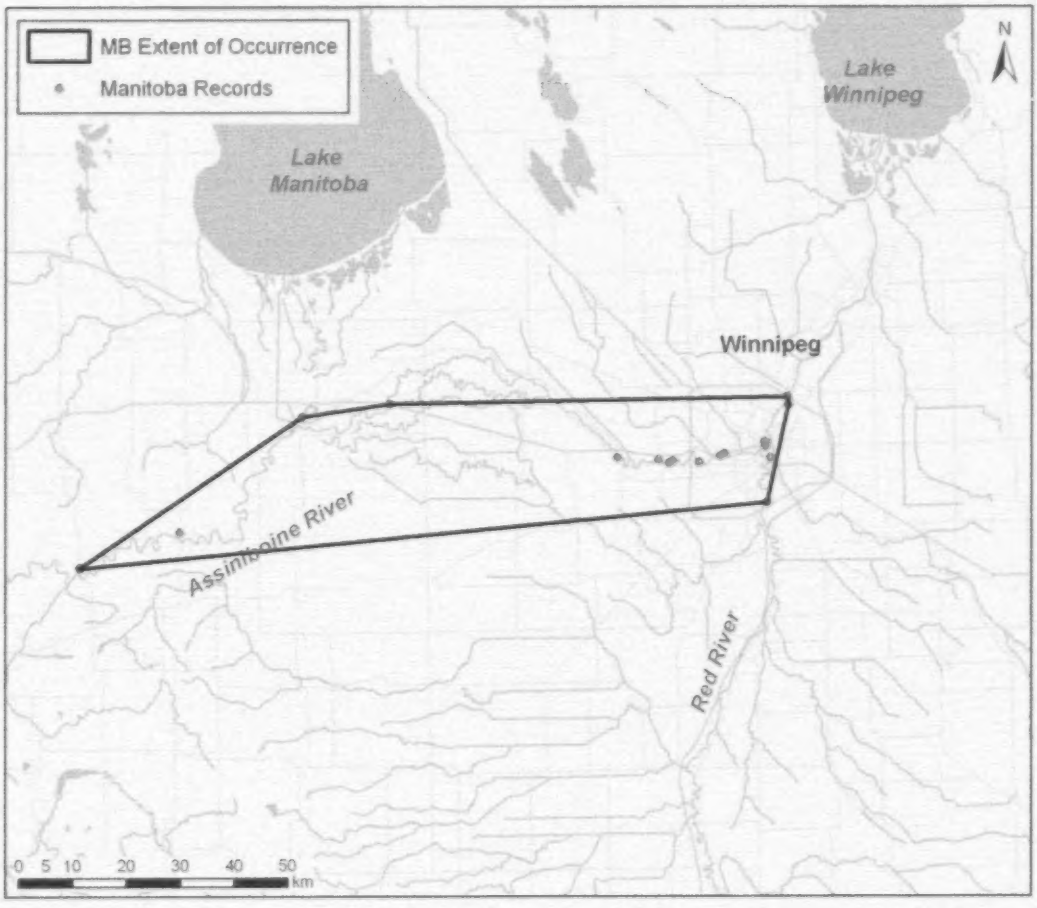

Figure 14. Calculation of the extent of occurrence (EO) for the Manitoba occurrences, which is 2491 km^2 (using discrete records or Winnipeg as a continuous location).

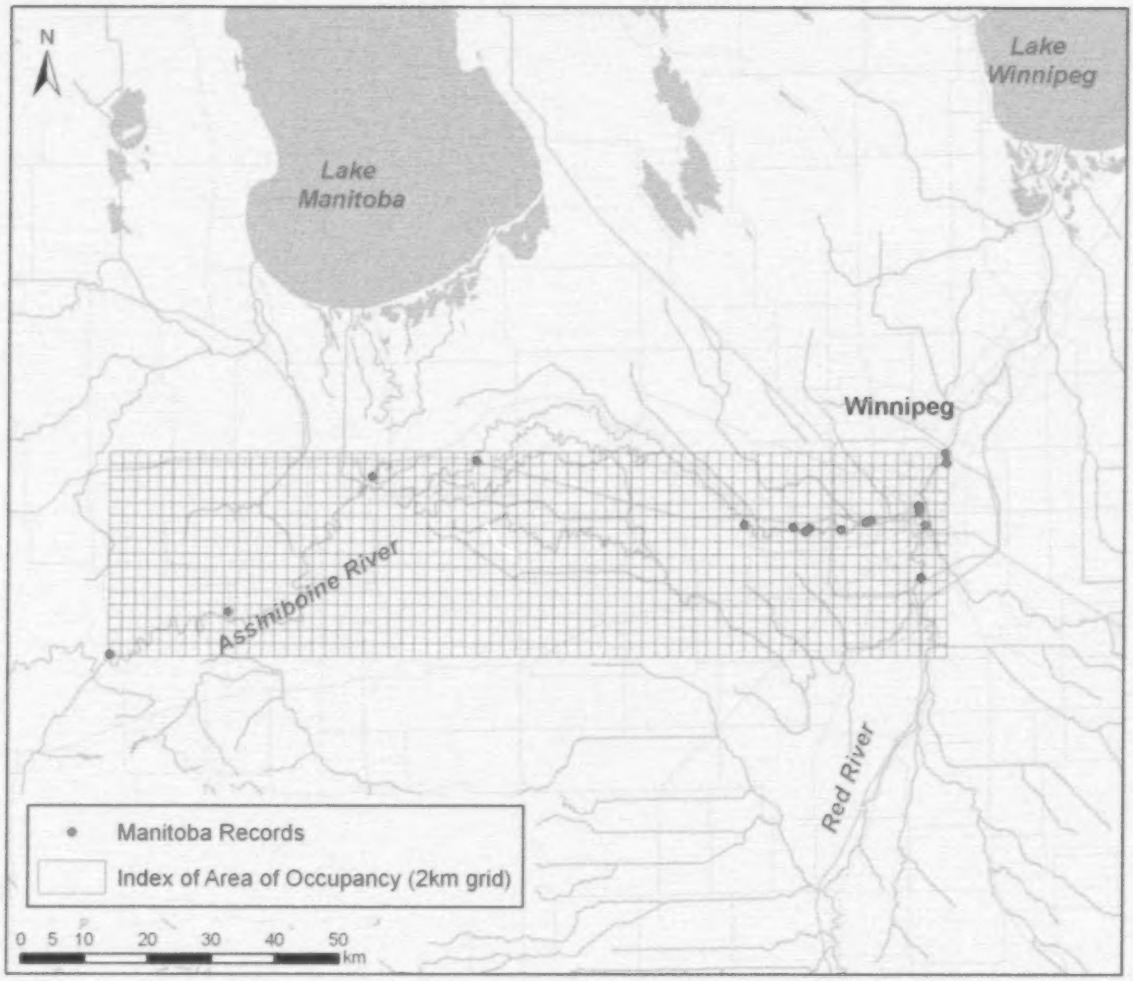

Figure 15. Calculation of the index of the area of occupancy (IAO) for Manitoba. It is 56 km^2 using a 2 x 2 km grid and discrete known records. If the Winnipeg records are considered one continuous location then the IAO is 168 km^2 (42 vs 14 squares).

Riverine Clubtail has not been observed in northwestern Ontario, but it has been recorded from two locations (Manitou Rapids, Vidas Landing) on the Minnesota side of the Rainy River (Steffens and Smith 1999), and may yet be confirmed from the Canadian side.

Search Effort

Quebec

Perron (pers. comm. 2012) has searched approximately 60 km along the St. Lawrence River between île d'Orléans and Deschambault near Quebec City, but there are over 350 kilometres upstream to Hull along the St. Lawrence and Ottawa rivers where it might be found in suitable habitat (Perron and Ruel 1998). The Riverine Clubtail may be present farther upstream along the Ottawa River or its tributaries (Ménard 1996), although there has been some search effort there, at least on the Ontario side (OOA 2005). At least 700 hours of survey efforts for Odonates has been conducted on the Ottawa River (mostly the Ontario side), including searches for exuviae (C. Jones, P. Catling pers. comm. in COSEWIC 2010b). There is relatively limited road access to many Quebec tributaries of the Ottawa and St. Lawrence rivers, and there are fewer odonatologists in Quebec than in Ontario (Ménard pers. comm. 2012). Given that the Riverine Clubtail was found on two additional Quebec rivers during 3 days of targeted surveys in 2011, additional surveys would likely extend its known range. On the other hand, Ménard (1996) spent considerable effort searching for this species in Quebec before finally observing it and Perron (2011 pers. comm.) found it at only one location after searching approximately 60 km of shoreline along the St. Lawrence River near Quebec.

Ontario

Targeted Surveys

At the time of the discovery of this species in Ontario in 1999 (Catling *et al.* 1999), Catling made brief surveys of Kettle and Catfish Creek without finding Riverine Clubtail. Prior to this and after this there were general dragonfly surveys of a number of southwestern Ontario rivers and creeks resulting in thousands of records being placed in the Ontario Natural Heritage Information Centre Database. On July 13 to 15, 2008 Harris and Foster (COSEWIC 2010) surveyed by canoe a 6 km stretch of Big Otter Creek and 7.5 km of Big Creek and checked 13 stream crossings for Laura's Clubtail and Riverine Clubtail. Unsuccessful searches for adults and exuviae were also conducted within 100 m of bridges on Little Otter, Catfish, South Otter, Venison, Deer, Silver, and Dedrick's creeks as well as Tate Drain. A half-day survey of 3 hours near crossings on Deer and Big creeks was also conducted in August 2010 (Foster and Harris 2011). Between July 13 and August 22, 2011, Solymar and Timpf conducted targeted surveys for *Stylurus* adults and exuviae (but not larvae) on Big, Big Otter, Little Otter, South Otter, and Venison creeks (EarthTramper Consulting Inc. 2011; Solymar pers. comm. 2012). Surveys totalled 156 hours and included 20 km of canoe survey on Big Otter and 15 km on Big Creek (Solymar, pers. comm. 2012). Solymar and Timpf also searched nine bridge crossings on Big Creek between McDowell Road (Regional #1) and Concession #1 road on July 13, 20, and August 8 2011. Roads and road shoulders were inspected for adult dragonfly mortalities from collisions with passing vehicles and creek banks were searched for exuviae. Searches were also conducted at

bridge crossings along South Otter Creek (6 sites), Little Otter Creek (4 sites) on July 24th, and Venison Creek (8 sites) on August 10th (EarthTramper Consulting Inc. 2011). Approximately two person-days of targeted surveys were conducted unsuccessfully in June 21-24, 2010 at nine sites along the Rainy River in northwestern Ontario, with an additional 3 hours of survey at two sites in July 2011 (Foster and Harris 2010; Harris and Foster 2011). No other targeted surveys for Riverine Clubtail are known to have been undertaken in Ontario.

General Surveys

Apart from Big Otter and Big Creek, there are no other records (Table 2) in the Ontario Odonate Atlas (OOA 2005), which has over 60,000 records encompassing all of the potentially suitable rivers in southwestern Ontario and many in southern Ontario. Maps of Ontario Odonate survey effort to 2003 showing where it has not been found despite general surveys are available in Jones (2003) and that map covers an extensive area but of course general survey effort now extends beyond the 2003 map. It seems unlikely that this species occurs elsewhere in the Carolinian region of southwestern Ontario (P.M. Catling, C. Jones, pers. comm., 2011). Rivers in this region have been relatively well surveyed (Thames, Sydenham, Grand, etc.) with thousands of hours and several thousand dragonfly records including both adults and a substantial representation of exuviae. Occurrences outside the Carolinian region of southern Ontario in rivers draining into Lake Huron is a possibility, but even these rivers, including the Nottawasaga and the Saugeen, have been visited by experienced Odonatists on more than 50 occasions over the past decade without any good evidence of Riverine Clubtail. If Riverine Clubtail did occur in these areas, it could still be considered part of the distinct Lake Erie DU and may still be considered at risk since there would still be threats to a substantial portion of the population. Although many northern Ontario rivers have been surveyed, there is also a possibility of occurrences there, particularly on the Mississagi and Goulais rivers, but such occurrences would still meet the criteria for 3 designatable units and they would belong to the Boreal Shield group.

Manitoba

Compared to Ontario, Manitoba has had less Odonate survey effort (MDS 2012), and the Riverine Clubtail was only discovered there during Hughes and Catling's 2005 surveys. For this status report approximately 15 hours of survey were conducted in late June and early July, 2010-2011 at 23 sites on the Assiniboine, Red, Souris, and Cypress rivers (Foster and Harris 2010; Harris and Foster 2011). Otherwise, there has been little or no targeted search effort for this species outside of Winnipeg. Although 2010-2011 surveys were timed to coincide with emergence, flood conditions in both years made finding exuviae difficult, but continued presence at existing locations in Winnipeg was confirmed. No new locations for Riverine Clubtail were found. The Assiniboine and Red rivers extend into Saskatchewan and North Dakota respectively, but no targeted surveys have been conducted and Riverine Clubtails have not been reported from these jurisdictions.

Most Canadian records for this species are of exuviae or emerging/teneral adults. Adults are difficult to find and capture, because presence is extremely dependent on conditions during the survey and seasonality of flights. Exuviae and larval surveys are more reliable indicators of presence, but are dependent on water levels. The Riverine Clubtail is probably more widespread and abundant in Canada than current records indicate, given the wide variety of habitats that it inhabits (Table 3) and the difficulty in surveying adults, but it is most likely that new occurrences will be found in the eastern and western extremes of its Canadian distribution and perhaps in the Lake Huron region. The central Lake Erie region may represent a true disjunction.

HABITAT

Habitat Requirements

Riverine Clubtail larvae inhabit a wide variety of riverine habitats ranging in size from the St. Lawrence River to small creeks (Table 3, Figures 16-20). Larvae are typically found in microhabitats with slow to moderate flow and fine sand or silt substrates (Catling *et al.* 1999; Harris and Foster 2011). In parts of their US range, they also inhabit faster flowing rivers with gravel substrates (B. Leppo pers. comm. 2011; Michigan Natural Heritage Inventory 2007; Paulson 2009a). The species reportedly prefers relatively clean waters (Michigan Natural Heritage Inventory 2007), but habitat in Canada includes the Red and Assiniboine rivers with relatively high turbidity and elevated concentrations of phosphorus and nitrogen (Rosenberg *et al.* 2005; Harris and Foster 2011). Although it is found on the St. Lawrence at Quebec City, it is not known at what point salinity will limit habitat suitability downstream (Perron pers. comm. 2011). Larval Olive Clubtail (S. *olivaceus*) live commonly in tidal waters on the lower Columbia River (COSEWIC 2011). There are no North American records for Riverine Clubtails in lakes, and it is not known if it persists in any of the reservoirs created by dams on the Gatineau or other rivers in Canada. Some clubtail species that are normally found in lotic environments also develop in lakes at the northern edges of their ranges, presumably where shoreline wave action sufficiently mimics flowing water (Paulson pers. comm. in COSEWIC 2011).

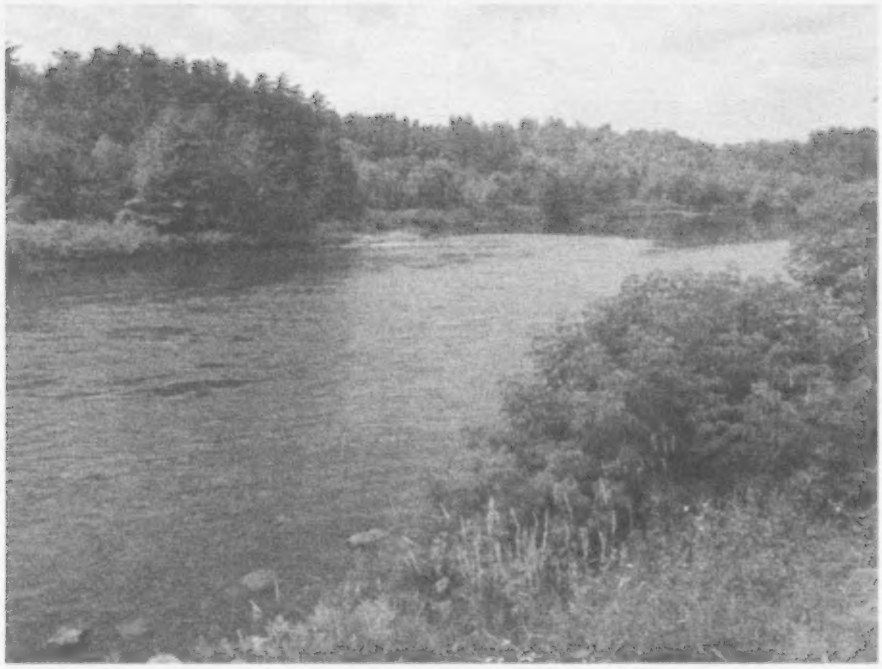

Figure 16. Riverine Clubtail habitat on Gatineau River QC, July 3, 2011 (looking N upstream), approximately 1 km upstream from the initial 1928 record.

Figure 17. Bar on Picanoc River QC where Riverine Clubtail 6 exuviae and 1 larva were collected July 4, 2011 (facing E).

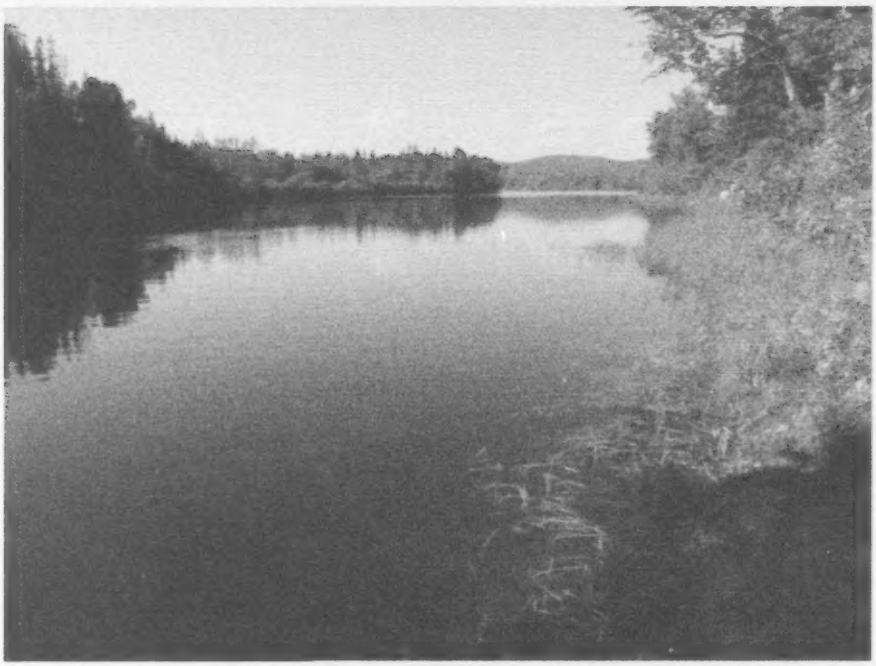

Figure 18. Riverine Clubtail habitat on the Coulonge River, July 4, 2011 (looking NW upstream).

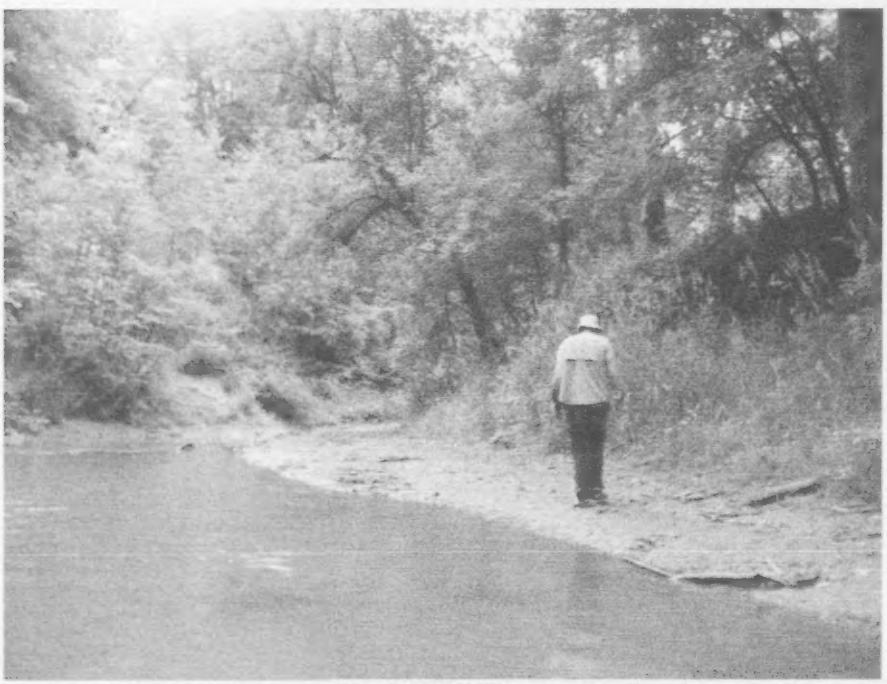

Figure 19. Riverine Clubtail habitat on Big Otter Creek, July 18, 2008 (looking NW downstream).

Figure 20. Riverine Clubtail habitat on the Red River at Winnipeg, opposite The Forks, July 7, 2011 (looking N downstream).

Riparian forest provides cover for tenerals and adults, although habitat also includes urban rivers through municipal parks in the cities of Winnipeg (Figure 20) and Gatineau where trees are present but continuous forest cover is absent (Harris, pers. obs.). This urban habitat is likely much less desirable and may even be explained by wash and drift from more appropriate habitats upstream. After emerging, adults tend to disperse from the riverbanks to the forest canopy to feed (Michigan Natural Heritage Inventory 2007). In Manitoba, adults were also captured in grasses on the riverbank (Hughes and Catling 2005).

Habitat Trends

There is no definite information on habitat trends. As with other riverine dragonfly species (COSEWIC 2008, 2010a, 2010b), water regulation, water pollution, and invasive species may be impairing habitat. Habitat at the Ontario locations is projected to decline because of the limited buffering effect of the small size of the two creeks and increasing pressure of development in the area leading to increased water withdrawal and pollution. The three regions differ substantially in present and projected impacts on habitat.

Quebec

The watershed of the Ottawa River (including the tributary watersheds of the Gatineau, Coulonge, and Petite-Nation rivers) is over 80% forested and about 4% urban and agricultural (Thorp *et al.* 2005). In general, water quality is relatively unpolluted in the Gatineau, Coulonge, and Petite-Nation rivers (Ottawa Gatineau Watershed Atlas 2012) and overall water quality on the Gatineau River has improved from 1979 to 1994 (MDDEP 2012). Industrial effluent and sewage downstream from Ottawa / Hull have caused some impairment of water quality on the Ottawa River (Thorp *et al.* 2005). Riverine Clubtail populations on the St. Lawrence River face potentially higher levels of pollutants originating from the Great Lakes basin, but monitoring has shown no marked trends in increased nutrient loading or suspended solids (MDDEP 2012). Although there are instances of impaired water quality up to 50 km downstream of Montreal, water quality is "satisfactory" near the Quebec City occurrences of the Riverine Clubtail (MDDEP 2012). Despite recent improvement, water quality has declined compared to the pre-European era, but what, if any, impact there has been on the Riverine Clubtail is unknown.

Construction of dams for hydroelectricity, recreation, and other purposes may have degraded Riverine Clubtail habitat by converting potentially suitable riverine habitat into lentic reservoir habitats, and by altering natural hydrologic regimes. The main channel of the Ottawa River has seven dams and there are over 300 dams on its tributaries (Thorp *et al.* 2005). There are four dams on the Gatineau River, including the Chelsea Dam immediately upstream from the Riverine Clubtail occurrence at the City of Gatineau (Ottawa Gatineau Watershed Atlas 2012). The Mercier Dam created the 300-km^2 Baskatong Reservoir in 1927 and the 434-km^2 Cabonga Resevoir was created in 1928 (GRWC 2012). There is also the Dozois Reservoir, and flowage throughout the Gatineau River is strongly controlled to reduce spring peaks (MDDEP 2012). On the Coulonge River, a hydroelectric dam was built in 1994 at the head of the Grandes Chutes (Gouvernement du Québec 1992). This dam is immediately downstream of a recently discovered Riverine Clubtail occurrence, and may have raised water levels and altered the flow regime in this reach of the river (data on water level changes are unavailable). The mouth of the Rivière de la Petite Nation was flooded by the Carillion hydroelectric dam on the Ottawa River; the Riverine Clubtail has only been found above the waterfalls near Plaisance on this river.

There is a long history of log drives down the Ottawa and St. Lawrence rivers and most of their larger tributaries including the Gatineau and Coulonge rivers. For almost 150 years logs were run down the Coulonge River, with the last spring drive occurring in 1982. The last log drive on the Gatineau occurred in 1993, with 587,000 m^3 floated downriver in 1986 (MDDEP 2012). The impacts from log drives on Riverine Clubtail habitat is unknown, but deposition of logs, bark, and woody debris on river bottoms may have buried their preferred silt and fine sand substrates (GRWC 2012).

Ontario

The watersheds of Big Creek and Big Otter Creek are about 20% forested and about 78% farmland (Lake Erie Source Protection Region Technical Team 2008). Nitrate and phosphorus concentrations in the Big Otter and Big creek watersheds consistently exceed the Canadian Guideline and Provincial Water Quality Objectives and are the most serious nutrient issues in the watersheds (Lake Erie Source Protection Region Technical Team 2008). Intensive agriculture and fertilizer application in the watersheds are probably the most significant source of these nutrients. Chloride concentrations associated with road salting, sewage treatment plant effluent, and other human sources are increasing at most sites in the Norfolk Sand Plain and generally in southern Ontario rivers (Lake Erie Source Protection Region Technical Team 2008; Todd and Kaltnecker 2004).

There are dams on Big Otter Creek upstream of Tillsonburg, at Norwich and at Otterville. Big Creek has a dam and reservoir at Teeterville (upstream from Delhi) and dams on its tributaries: North Creek and South Creek. Deer Creek, a major tributary of Big Creek, also has a reservoir. The dams are operated for recreation, water supply, flood control and flow augmentation (Lake Erie Source Protection Region Technical Team 2008). Flow regimes show the influence of reservoirs with spring flood peaks that are somewhat attenuated compared to an unregulated stream (COSEWIC 2010a). Numerous tributaries of Big Creek and Big Otter Creek are also regulated to supply water for irrigation. Agricultural and other water users within the watershed can significantly reduce stream flow within Big Otter Creek (Lake Erie Source Protection Region Technical Team 2008).

Manitoba

Much (70-80%) of the Red and Assiniboine River watershed consists of agricultural land (Armstrong 2002; Rosenberg *et al.* 2005) and the area faces increasing development pressures. The Assiniboine and Red rivers have high levels of nitrogen and phosphorus due to inputs from naturally fertile prairie soils and anthropogenic inputs from municipal, industrial, and agricultural sources (Armstrong 2002; Rosenberg *et al.* 2005). Increased nutrient input (eutrophication) has resulted in increased algal blooms. The die-off and decay of algal blooms consumes dissolved oxygen, leading to extensive fish kills (Armstrong 2002) and possibly degraded habitat for dragonfly larvae. Water quality is said to be improving in the Manitoba Rivers (see under **THREATS AND LIMITING FACTORS**).

Dams may have been among the most significant human impacts on the Red and Assiniboine rivers (Rosenberg *et al.* 2005) and they continue to exert an influence. The Shellmouth Dam on the Assiniboine greatly influences the river hydrograph, shifting the annual minimum discharge from midwinter to late autumn. Water is discharged in winter to reduce the risk of spring flooding. The effects of these flow variations on dragonflies and other aquatic life are unknown. The Lockport Dam, (downstream of known Riverine Clubtail occurrences) maintains water levels in Winnipeg at 2 to 3 m above normal summer levels (Rosenberg *et al.* 2005).

BIOLOGY

Little information is available about most aspects of Riverine Clubtail biology. Much of the information in this section was derived from descriptions of other river-inhabiting clubtails in Walker (1958), COSEWIC (2010a), and supplemented with information on behaviour and ecology from Corbet (1999).

Members of the genus *Stylurus* are referred to "hanging clubtails" for their habit of hanging vertically when perched on streamside vegetation (Dunkle 2000). The Riverine Clubtail is apparently less wary than other hanging clubtails and relatively easily approached (Dunkle 2000).

Life Cycle and Reproduction

The dragonfly life cycle consists of an aquatic larval stage and terrestrial adult stage. Adult Riverine Clubtails fly from late June to early August in Canada, with peak numbers in early July (Table 2; Jones *et al.* 2008). Farther south in their range, the flight season extends from May to September (Paulson 2011). Emergence of Riverine Clubtails has been recorded in Canada from June 26 (Walker 1928) to July 5 (Harris and Foster 2011). Mating adult pairs have been observed on July 8 (de March pers. comm. 2011) and July 13 (Harris and Foster 2011).

Adults inhabit the floodplain corridor and apparently forage in the canopy of the surrounding forest (Jones *et al.* 2008). In the Midwest the species is reported to forage in thick grass and brush (Dunkle 2000).

When ready to breed, males patrol in fast, low flights over the stream from mid-morning until late afternoon (Catling *et al.* 1999; Dunkle 2000). Males tend to fly over mid-river, but also cruise over slow-moving pools (Paulson 2011). They do not appear to hold territories as some other gomphids do, and Catling *et al.* (1999) observed more than 25 adults along a 250-yard stretch of Big Otter Creek.

Before copulation, the male transfers sperm from the end of the abdomen to the secondary genitalia beneath the second abdominal segment. Upon encountering a female, the male grasps her by the thorax with his legs and then clasps the base of her head with his abdominal claspers. The pair flies in tandem while the female bends her abdomen forward so that her ovipositor contacts the male's secondary genitalia, where she picks up the sperm. Eggs are laid in the current over the open stream (NatureServe 2012). On average, female dragonflies deposit 200 to 300 eggs, but over 5000 were produced by a female Plains Clubtail (*Gomphus externus*, Walker 1953).

Eggs probably require at least five days and perhaps up to a month or more to hatch (Walker 1953; Corbet 1999). Larvae burrow into the top few centimetres of the river sediment, breathing through the tip of the abdomen raised above the sediments (Corbet 1999). Riverine Clubtail larvae were sieved from the upper 20 cm of sediments in 20 to 30 cm of water and within 2 metres of shore along the Gatineau and Petite-Nation rivers in 2011(Harris and Foster 2011).

The duration of the larval stage of the Riverine Clubtail is undocumented, but probably lasts two or more years. Because the eggs likely hatch within a week of deposition within the stream, a generation time of two years is thought to be characteristic of this species as with most other members of the family Gomphidae (COSEWIC 2008, 2010a). Other gomphids at temperate latitudes in Europe require at least three to four years to reach adulthood (Walker 1953; Corbet 1999). Duration of the larval stage may be shorter where food is abundant.

Before the final moult, larvae crawl onto the stream bank or vegetation close to the edge of the stream. Larvae have been observed emerging near midday (10:00-14:00), even on sunny days (Ménard 1996; Harris and Foster 2011). Exuviae distribution along river is not random and they appear to be most abundant on sandy banks or bars above or below swift water. Riverine Clubtails typically emerge within 20-60 cm from water's edge (farther on more gentle slopes) on a bare sandy bank (Ménard 1996; Harris and Foster 2011). Flood conditions on the Red River in 2011 forced emerging larvae to crawl up into lawns and into forest vegetation (Harris and Foster 2011). After emergence, teneral (newly emerged) adults make short flights to shrubs on the riverbanks. Dozens of dragonflies, including some definitely Riverine Clubtails, were observed at heights of 1 to 3 m within 20 m of the riverbank on the Red River in July 2011 (Harris, pers. obs.). After a period of feeding (generally lasting a week or more in other dragonfly species), adult males return to the stream to breed (Walker 1953).

Adult Riverine Clubtails are probably generalist and opportunist predators, feeding on small flying insects (Walker 1953). Much of their feeding presumably takes place in the forest canopy, where adults tend to spend most of their time. Larvae ambush prey from the sediments using their prehensile labium. Young clubtail larvae feed on very small prey (e.g. ciliates and rotifers) and the size of the prey increases as the larvae grow (Corbet 1999). Larger larvae feed on bottom-dwelling macroinvertebrates such as chironomid midges, tubificid worms, and burrowing mayflies (Bright and O'Brien 1999).

Physiology and Adaptability

Physiological requirements of the Riverine Clubtail are not documented. Larvae are probably sensitive to pesticides, especially organochlorides and organophosphates (Corbet 1999). Effects of pollutants on odonate larvae include slow growth, developmental deformities, and behavioural abnormalities (Corbet 1999). Biological accumulation of persistent chemicals may be significant given their predatory diet and relatively long life cycle. Biological oxygen demand (BOD) greater than 10 mg/l cannot be tolerated by most odonate larvae (Corbet 1999).

The Riverine Clubtail has demonstrated a certain degree of adaptability in that it inhabits a wide range of river sizes (Table 3) across a wide range of latitude and longitude. It has been able to persist in the Gatineau, St. Lawrence, Red and Assiniboine rivers, despite nutrient enrichment, water level alterations from dams, and other habitat changes, but information on the severity of these potential threats in these places is lacking.

Dispersal and Migration

The Riverine Clubtail is non-migratory (NatureServe 2012). The average distance travelled between reproductive and roosting or foraging sites is generally less than 200 metres in dragonflies (Corbet 1999).

Other stream-dwelling dragonflies tend to remain close to their breeding sites, moving short distances upstream and downstream and very short distances inland (Corbet *et al.* 1960). Unlike dragonflies inhabiting ephemeral pools or other seasonal habitats, the Riverine Clubtail lives in relatively stable habitats where the requirement for dispersal is lower and the likelihood of finding unoccupied suitable habitat is small. Their flight behaviour of remaining close to the river surface or in forest cover makes them less vulnerable to passive dispersal by winds than are odonates that habitually swarm above the canopy. Downstream dispersal of eggs or young larvae by river currents could result in establishment of new populations where suitable unoccupied habitat exists.

The Canadian occurrences are separated by a minimum of 200 km from the nearest known locations in the US, and US and Canadian sites probably constitute separate populations.

Interspecific Interactions

The Riverine Clubtail has no known symbiotic relationships. Both adults and larvae are probably generalist predators, feeding on a wide range of prey species within the suitable size range.

A closely related species, Laura's Clubtail (*Stylurus laurae*), also occurs in Big Creek and Big Otter Creek and these two species may compete for food in both the larval and adult stages. In Quebec, the Riverine Clubtail occurs in the same sections of river as over 20 other species of dragonflies (Harris and Foster 2011), but interactions among the species are unknown.

Predators on Riverine Clubtail larvae may include fishes such as Smallmouth Bass (*Micropterus dolomieu*), bullheads (*Ameiurus* spp.), Northern Pike (*Esox lucius*), and Rock Bass (*Ambloplites rupestris*), all of which were observed at Quebec sites in 2011. Lake Sturgeon (*Acipenser fulvescens*) may be important predators at some Manitoba and Quebec sites. Emerging larvae and teneral adults are particularly vulnerable to predation by birds, frogs, and Raccoons (*Procyon lotor*) among many other species. Potential predators on adults include insectivorous birds, especially swallows (Hirundinidae). A large dragonfly, Dragonhunter (*Hagenius brevistylus*), was observed at several Quebec sites and is a potential predator on adult Riverine Clubtails.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Most surveys for the Riverine Clubtail in Canada have been primarily to determine their presence/absence rather than measuring abundance (see **Search Effort**). Initial records for Quebec (Walker 1928), Ontario (Catling *et al.* 1999), and Manitoba (Hughes and Catling 2005) were made opportunistically during more general odonate surveys.

Most surveys have consisted of searches for exuviae and adults along riverbanks, typically within several hundred metres of bridges or other access points. This species is difficult to detect as adults because they have a relatively short emergence period and typically forage high in the canopy or patrol mid-river (Jones *et al.* 2008; Paulson 2011). As a result, exuviae surveys are the most effective technique (Vogt pers. comm. 2011), and the majority of Canadian records are larvae, exuviae, or teneral adults (Table 4). Larvae have been caught emerging on sandy riverbanks and kept until emergence to confirm identification (Walker 1928; Menard 1996; Harris and Foster 2011). Sieving for larvae by pulling a 5 mm mesh metal sieve through sand and silt substrates in shallow water along river margins has also been effective (Harris and Foster 2011).

Table 4. Summary of Riverine Clubtail abundance observed in Canada (A = adults; I = immatures).

SITE	1928		1995		1997		1999		2000		2002		2004		2008		2009		2010		2011		2012		Total
	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	A	I	
MB																									
Assiniboine River													3	14	2		1		5						**25**
Bunn's Creek																	2		1						**3**
Red River													1	2					2		4	3			**12**
ON																									
Big Creek									3							5							3		**11**
Big Otter Creek							29		26		3				2	5							8		**73**
QC																									
Gatineau River	4				3																1	1			**9**
Rivière Coulonge																						2			**2**
Rivière de la Petite-Nation			4																		1	2			**7**
Rivière Désert				1																					**1**
Rivière Picanoc																						8			**8**
St. Lawrence River					2	6																			**8**
Rivière Bastican																							1		**1**

More extensive and quantitative surveys for *Stylurus* (*S. amnicola* and co-occurring S. *laurae*) exuviae and adults have been conducted by canoe along Big Otter and Big Creek, Ontario. On August 10-12 2004, P. Burke, C. Jones, R. Russell and D. Sutherland canoed approximately 6 km of Big Otter Creek from Eden Line south to Heritage Line and surveyed the creek at bridge crossings downstream of this section (COSEWIC 2010a). They did not find any Riverine Clubtails, although they did collect 20 Laura's Clubtail larvae (OOA 2005). On July 13, 2008 Harris and Foster canoed the same 6-km stretch of Big Otter Creek and found 5 Riverine Clubtail exuviae, as well as two copulating adults. The next day they surveyed 7.5 km of Big Creek and found an additional 5 exuviae. B. Solymar conducted 20 km of canoe surveys on Big Creek and 15 km on Big Otter Creek from August 1 to 22, 2011 (after the peak of the emergence), but collected only one Riverine Clubtail exuvia (10 others were collected in late July during searches near bridges).

Abundance

Estimating total population sizes for odonates is difficult (Corbet 1999) and Canadian populations of the Riverine Clubtail are not known well enough to provide reliable population estimates. Collection data suggest that the species is rare (less than 100 adults and a similar number of exuviae have been recorded for all of Canada; Table 4), but adults are difficult to collect and search effort for exuviae has been low. The discovery of seven new occurrences in the Manitoba and Quebec regions since 1999 suggests that there may be additional occurrences in the eastern and western portions of the species' range.

Most Canadian records consist of six or fewer adults and/or emerging larvae at a given date and site (Table 4). Catling *et al.* (1999) observed up to 10 adults at one time along approximately 100 m of Big Creek, with approximately 25 adults estimated along the 250 m stretch examined on July 11, 1999. Riverine Clubtails do not appear to have mass emergence like some other clubtails particularly *Ophiogomphus* (snaketails) where hundreds or thousands of individuals may emerge at one location over the period of a few days (e.g., Foster and Harris 2007). Four emerging larvae were found June 30 1995 above the falls on the Rivière de la Petite-Nation and "several dozen" exuviae were subsequently recovered from this site (Perron 1996).

Because adult Riverine Clubtails are difficult to observe and are easily confused in flight with other co-occurring *Stylurus*, exuviae hold the greatest promise for estimating abundance.

No global abundance estimate is provided by NatureServe (2012) for Riverine Clubtail. According to Paulson (2009b), the Riverine Clubtail is a "reasonably widespread and locally common species".

Fluctuations and Trends

Trends in Canadian population size are unknown due to lack of repeated, quantitative surveys.

The first Canadian record for the Riverine Clubtail was from the Gatineau River in 1928 and the species was not documented again in Canada until the mid-1990s when it was found at three other locations in Quebec (Pilon and Lagacé 1998). It was discovered in Ontario in 1999 (Catling *et al.* 1999) and in Manitoba only in 2004 (Hughes and Catling 2005), but was probably established at these locations prior to discovery. The Riverine Clubtail continues to persist near the mouth of the Gatineau River at the site of its original discovery over 80 years ago.

Fieldwork conducted in 2011 and 2012 also indicates that the Riverine Clubtail continues to persist on the Gatineau River near Maniwaki as well on the Rivière de la Petite Nation in Quebec, on Big and Big Otter creeks in southern Ontario, as well as on the Assiniboine and Red rivers in Manitoba. This is not surprising given the shorter time period elapsed since prior surveys on these systems. The number of known sites in Canada where the Riverine Clubtail is present has at least not decreased; in fact, it has grown with increased survey effort over time.

Although there have been repeat visits on Big Otter and Big creeks, the timing of canoe surveys in particular has not been consistent, which can greatly affect the number of exuviae found and obscure any trends.

The Riverine Clubtail has not shown a range-wide population decline (Paulson 2009b). Similarly, contacts with the conservation data centres throughout the range of the Riverine Clubtail show no clear population trends (Table 2). The species is apparently declining in North Carolina (LeGrand 2011), and known only from historical records in Georgia (Beaton. pers. comm. 2011), Maryland (Frye pers. comm. 2011), New York (NatureServe 2012), and Pennsylvania (Leppo pers. comm. 2011). In contrast, it is more common than initially thought in Wisconsin (Smith pers. comm. 2011) and New Hampshire (Cairns pers. comm. 2011) and was recently discovered in Maine (MDDS 2009).

Rescue Effect

The likelihood of natural dispersal from US locations is relatively low and genetic exchange between Canadian and US populations is probably very infrequent or non-existent. Rescue cannot be accomplished from adjacent jurisdictions when those populations are imperiled, which is the case for all adjacent US states. Quebec populations are over 300 km from the nearest known records in New York (SH), Vermont (S1), New Hampshire (S3), and Maine, where it is known from only one exuvia. Southern Ontario locations are over 300 km from the nearest known populations in Ohio (S2) and Michigan (S1S3), and there is little suitable intervening habitat. Manitoba populations are approximately 200 km from the nearest known occurrence in Minnesota, where they are considered uncommon statewide (Mead pers. comm. 2011). The Riverine Clubtail is not known from adjacent North Dakota. If extirpated, recolonization at the Canadian periphery of their range would presumably take a very long time or may never happen given the non-migratory behaviour of the adults.

THREATS AND LIMITING FACTORS

The situation with threats at the Ontario region sites appears to be more urgent because the habitat involves small creeks (Table 3). Also threats are well documented at the Ontario sites but much less well known at the Quebec and Manitoba sites. This section therefore begins with a general discussion and reference to the Quebec and Manitoba regions and then concludes with a detailed analysis of threats in the Ontario region occurrences.

Aquatic habitat degradation through water regulation and pollution are probably the most significant threat to the species overall. Invasive species, alteration of riparian vegetation, accidental deaths through vehicle collisions, and boat wakes are also potential limiting factors. In general, clubtail species are sensitive to changes to the aquatic environment because their larvae live in the sediments of the streams for two or more years (Gehring 2006). On a global scale, there are no threats presently affecting this species (Paulson 2009b), but some populations face threats from local sources.

Dams are present in all of the watersheds occupied by the Riverine Clubtail and are a historical and ongoing threat to the species. Potential impacts of dams on Riverine Clubtail habitat include the loss of lotic habitat in reservoirs, higher water temperatures (as groundwater-fed streams are held in reservoirs), alteration of shoreline vegetation, and sediment accumulation resulting from the loss of flushing effect from spring freshets (P.M. Catling, pers. obs.) and an unnatural sequence of water levels. Although the species is able to persist immediately downstream from the Chelsea Dam near the mouth of the Gatineau River and on the intensively regulated Red and Assiniboine rivers, population trends are unknown, and construction of these dams likely caused loss of suitable habitat in the reservoirs and is a continuing threat based on some of the effects outlined above.

Water pollution from herbicides, pesticides, and sewage from municipal, agricultural, and industrial sources can directly kill dragonfly larvae or increase bacterial and algae growth in their habitat (Gehring 2006). The Riverine Clubtail appears to be at least somewhat tolerant of water pollution and nutrient enrichment given its persistence in streams through intensively agricultural areas in central Illinois ("the Great Corn Desert"; Vogt pers. comm. 2011) and in the Red and Assiniboine rivers. However, populations are likely vulnerable to chemical spills and increasing human populations in these watersheds. Most of the Quebec occurrences of Riverine Clubtail are in relatively clean Rivers. The Assiniboine and Red Rivers in Manitoba have been rated as seriously polluted in the past but water quality is said to be improving (http://saveourseinenews.blogspot.ca/2007/12/manitoba-rivers-fail-pollution-tests.html).

Invasive species occupy most sites of the Riverine Clubtail in Canada, or are likely to be invaded by one or more. While we are confident that there is, or will be, an effect, it is unclear what it will be. Zebra and Quagga mussels (*Dreissena polymorpha* and *D. bugensis* respectively) and numerous non-native fish species occur in the St. Lawrence and Ottawa rivers (Thorp *et al.* 2005). Dams and rapids on the lower reaches of the Gatineau, Coulonge, and Petite-Nation rivers may act as a barrier for upstream dispersal of non-native aquatic species from the Ottawa River. Among the invasive species in the Red and Assiniboine rivers that are potential threats to the Riverine Clubtail are Common Carp (*Cyprinus carpio*), White Bass (*Morone chrysops*), Largemouth Bass (*Micropterus salmoides*), and Smallmouth Bass (Rosenberg *et al.* 2005). The Saskatchewan - Nelson watershed has fewer aquatic invasive species than in the Great Lakes watershed in part due to the absence of international shipping (Harris *et al.* 2006).

The threats of residential and urban development, agriculture, transportation, natural system modifications, and pollution, all discussed below with regard to the Ontario range, also apply to the portions of the Quebec and Manitoba occurrences, but much less information is available to understand the levels of significance of those threats in these areas.

Threats for Ontario Region of Occurrence

The following threats are in the order of NatureServe's "Threats Assessment Worksheet" (Master *et al.* 2009) and provide information on how the sheet was completed. The overall threat impact calculated was "very high." The threats are in the order of the worksheet and the numbers (1.1, 2.1 etc) correspond to numbers in the worksheet. Although some of these threats may be addressed through the recovery plan for the Endangered Laura's Clubtail (*Stylurus lauræ*, Pulfer *et al.* 2011), which occupies the same area, there has been no indication of substantial improvement up to this time.

(1) Residential and commercial development

As the land around a stream is converted from forest to roads, parking lots and cultivated lands, insects forced to use this modified landscape are subject to mortality by increased exposure to predators and insecticides. In increasingly urbanized areas predators that are subsidized by humans increase. Some of these, such as raccoons and grackles, swallows, martins, starlings, and others have an ability to find dragonfly larvae along streams, particularly during periods of emergence. Both the aquatic and the terrestrial habitat of the dragonfly are affected. (1.1 is restricted and moderate).

(2) Agriculture and aquaculture

Loss of groundwater recharge to runoff from corn and other crops. (2.1 is restricted and moderate).

(4) Transportation and service corridors

Collisions with cars could be a source of adult mortality where road crossings fragment the stream habitat (U.S. Fish and Wildlife Service 2001) and adjacent terrestrial habitat. Roads with traffic speeds greater than 50 km / hour probably pose the greatest risk, although large highways with wide cleared areas tend to kill fewer odonates (P. Brunelle pers. comm. 2007). There are 12 bridges on Big Otter Creek and seven bridges on Big Creek in or near Riverine Clubtail habitat. All these roads have speed limits greater than or equal to 50 km / hour. Although dragonflies may survive in low numbers under such conditions, an increasingly modified landscape may increase the vulnerability of a population. (4.1 is restricted and moderate).

(5) Biological Resources Use

Approximately 75 km of both Big Creek and Big Otter Creek have been treated with TFM (3-trifluoromethyl-4-nitrophenol) every 3-4 years on average since 1986-87 to control Sea Lamprey (*Petromyzon marinus*)(Sea Lamprey Control Centre, Sault Ste. Marie, unpubl.). Although dragonfly larvae appear fairly resistant to TFM (Smith 1967; Maki *et al.* 1975), impacts on their prey species and other aspects of the stream ecosystem are unknown. (5.4 is restricted and unknown).

(7) Natural system modifications

Big Creek and Big Otter Creek and their tributaries have dams and other water control structures and are regulated for flood control and other purposes. There are dams on Big Otter Creek upstream of Tillsonburg at Norwich and at Otterville. Big Creek has a dam and reservoir at Teeterville (upstream from Delhi) and dams on its tributaries; North Creek and South Creek. Deer Creek, a major tributary of Big Creek, also has a reservoir. It is not so much the construction of the dams that occurred in the past, as it is the ongoing impact of dams that is important with regard to threats. The dams are operated for recreation, water supply, flood control and flow augmentation (Lake Erie Source Protection Region Technical Team 2008). Small changes in the use of dams and water level regulation can cause changes to natural patterns of sediment accumulation and can alter water temperature regimes leading to major effects.

Large amounts of water are removed from Big Otter Creek and Big Creek for agricultural irrigation. Some of the new crops replacing tobacco also require extensive irrigation. There are 800 water takers on Big Creek of which 259 withdraw from surface waters and Big Otter Creek is also used extensively. Irrigation can significantly reduce summer flows in these creeks, particularly in dry summers (Lake Erie Source Protection Region Technical Team 2008) and reduce the habitat suitability by reducing wetted width, reducing water depth, increasing water temperature, and decreasing water quality by concentrating pollutants. It could increase larval vulnerability to chemical spills and sea lamprey control treatments. Increasing human populations in southern Ontario and global warming could put increased pressure on scarce water supplies and affect flows in Big Otter and Big creeks. Recently dry periods have resulted in substantial stress in the farming community and although there has been some planning to reduce future stresses, it has not addressed the needs of the Riverine Clubtail, or other aspects of the aquatic environment of the creeks (Shortt *et al.* 2004). Increasing demands are expected on the water resources in the Norfolk Sand Plain area (Wong and Bellamy 2005). (7.1 considered large and serious).

(8) Invasive and other problematic species

Many invasive aquatic species are present in Big Creek and Big Otter Creek and their tributaries. Common Carp, Round Goby (*Neogobius melanostomus*), and Curly Pondweed (*Potamogeton crispus*) are present in both creeks. Zebra Mussels apparently occupy the reservoir on Big Otter Creek upstream from Tillsonburg (A. Dextrase pers. comm. 2009). Rainbow Trout, also called Steelhead (*Oncorhynchus mykiss*), are known from Big Otter Creek and have recently increased in Big Creek through directed efforts to improve the fishery and the spring run. The impacts of these species on the Riverine Clubtail are unknown, but likely include predation, competition, increased turbidity (Common Carp), and changes in the stream community structure as a result of Curly Pondweed preventing burrowing of larvae and reducing flow rates that allow oxygen intake.

Round Gobies invaded Big Otter and Big creeks circa 2004 and are now fairly common and widespread. These highly aggressive and often abundant predators are likely the greatest invasive species threat in these systems (A. Dextrase pers. comm. 2009). Round Gobies feed on a wide range of benthic invertebrates (Phillips 2009), and Riverine Clubtail larvae would be particularly vulnerable when leaving the sediment at the time of emergence. Invasion of Round Gobies has altered the benthic invertebrate community of several eastern Lake Erie tributary streams (Krakowiak and Pennuto 2008). Other aquatic invasives are a continued threat given the proximity to Lake Erie where numerous other invasive species exist. (8.1 is large and serious).

(9) Pollution

There is already runoff from agricultural lands (the watersheds of Big Creek and Big Otter Creek are about 20% forested and about 78% farmland) and increasing development in the town of Tillsonburg is expected to place additional pressure on Big Otter Creek and the 1940 Delhi Wastewater Treatment Plant is under pressure (http://cd989.com/2012/03/45488/). Nitrate and phosphorus concentrations in the Big Otter Creek and Big Creek watersheds consistently exceed the Canadian Guidelines and Provincial Water Quality Objectives (Lake Erie Source Protection Region Technical Team 2008). Increasing phosphorus and nitrate levels could threaten Riverine Clubtail larvae by promoting eutrophication and decreasing dissolved oxygen availability. Intensive agriculture and fertilizer application in the watersheds are probably the most significant source of these nutrients (9.3 is large and serious). Chloride concentrations associated with road salting, sewage treatment plant effluent, and other human sources are increasing at most sites in the Norfolk Sand Plain and generally in southern Ontario rivers (Todd and Kaltnecker 2004; Lake Erie Source Protection Region Technical Team 2008;)(9.1 is restricted and moderate – slight). The frequency of water quality monitoring (eight samples per station annually) may be insufficient to adequately determine trends because changes can occur rapidly due to floods, rains, removals, spills, and discharges. Eutrophication and chloride content are generally increasing in streams of the Norfolk Sand Plain where the two creeks are located (Lake Erie Source Protection Region Technical Team 2008).

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

COSEWIC assessed both the Boreal population and the Prairie population of Riverine Clubtail as Data Deficient, and the Great Lakes population as Endangered in November 2012. The Riverine Clubtail is not currently protected under Canada's *Species at Risk Act,* the *Loi sur les espèces menacées ou vulnérable* du Québec (Act representing threatened or vulnerable species – R.S.Q.,c E-12.012b), the Ontario *Endangered Species Act*, 2007 or the Manitoba *Endangered Species Act*. It is not listed federally **in** the US, but Endangered in Massachusetts and Special Concern in New Hampshire (Table 1).

The Riverine Clubtail is not listed under the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES).

Non-Legal Status and Ranks

The Riverine Clubtail is ranked globally as G4 (Apparently Secure; last assessed in 2000, NatureServe 2012). At the national level it is N3 (Vulnerable) in Canada and N4 (Apparently Secure) in the US (NatureServe 2012, http://www.natureserve.org/explorer http://www.natureserve.org/explorer/ranking.htm).

At the state and provincial level it is ranked S1 (Critically Imperiled) in Ontario, S3 (Vulnerable) in Quebec, and is not ranked in Manitoba (M. Larrivée, pers. comm. 2012; NatureServe 2012). It is ranked SX (Presumed Extirpated) in Pennsylvania, SH (Possibly Extirpated) in Maryland and New York, S1 to S2 (Critically Imperiled to Imperiled) in five states and S3 to S3S4 (Vulnerable) in five states. The species is not ranked in 10 states (Table 1). Refer to Table 1 for comments on the S-ranks.

The Riverine Clubtail is listed as Least Concern by the International Union for the Conservation of Nature (Paulson 2009b). It is assigned a General Status rank of Sensitive in Canada and in Quebec and a status of May be at Risk in Ontario (no status is assigned for Manitoba) (CESCC 2011).

Habitat Protection and Ownership

None of the known Canadian occurrences of the Riverine Clubtail are in provincial or national parks. Several of the sites on the Red and Assiniboine rivers are in municipal parks where they receive a measure of protection. All Ontario occurrences at Big Otter Creek and Big Creek are on private land and road allowances. Most Quebec occurrences appear to be on private or Crown land, with the exception of the site at la Rivière de la Petite-Nation which is within a municipal and regional park, and one site near Quebec City that is adjacent to a municipal park.

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COLLECTIONS EXAMINED

None.